
GERMAN GUIDED MISSILES
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A battery of "Rheintochter R 1" anti-aircraft missiles.

German Guides Missiles

Neither the German "Flugkörper" nor the English-American phrase "guided missiles" accurately reflects the application of these devices which today play such a large role in the arms inventory of all countries. There were (and still are) five groups of these weapons, each serving quite different purposes.

1. medium- and long-range missiles
2. air-launched missiles
3. glider bombs
4. glider torpedoes
5. anti-aircraft missiles

What today is considered the most modern branch of service is, in reality, the continuation of ancient ideas. In China rockets with solid fuel engines were utilized for as incendiary devices as early as the year 1130. In 1916, French single-seat Nieuport fighters were toting 16 incendiary rockets which were employed against German airships with great success. The Zeppelin airship LZ 77 (commanded by Hauptmann Horn) was shot down over France on February 21st 1916 with just such rockets. On the German side, attempts were made to develop a similar weapon by mounting captured rockets on a Halberstadt D II single-seat fighter, but these attempts were not successful. As early as 1910, Wilhelm von Siemens, a son of the firms founding father Werner von Siemens, was occupying himself with preliminary research into gliding bombs fins by dropping them from balloons and airships. After the start of the war in 1914, this idea was rekindled. In early 1915, small glider models which could guided by electrical wire to a distance of 3000



A captured French Nieuport 16 single-seat fighter with air-launched rockets.



German Halberstadt D II single seater equipped with jury rigged incendiary rockets.

meters, were dropped from barrage balloons. In 1916 further successful drops from airships were conducted. In 1917, Siemens presented the *Reichsmarine-Amt* with gliding torpedoes which were tested aboard the airships Z XIII, L 25 and L 35. On 27 April 1918, however, a glider crashed at Jüterbog airfield, after which time all further testing was stopped. The last drop was conducted on August 2nd 1918 by the airship L 35 from an altitude of 1,500 meters near Potsdam. But because the airships proved to be too slow for these purposes, the sentiment was to utilize huge airplanes such as the Zeppelin-Staaken R IV (see: Nowarra, *Die Flugzeuge des Alexander Baumann, Podzun-Verlag*) for these purposes. A total of 100 of these torpedoes were built up to November of 1918.

Despite the ban imposed by the 1919 Treaty of Versailles, the *Heeres-Waffenamt* awarded developmental contracts in 1926 and 1927 for flight control and remote control systems. By 1929 there was already a flight remote control station in existence for aircraft. In 1930 the related testing was begun.

It was some time after the National Socialists (Nazis) came into power, specifically not until 1938, that the Wehrmacht began to take interest in the development of guidance methods, air-launched rockets, gliding bombs, torpedoes and other such weapons. An intensive development, however, did not take place until the middle of the Second World War.





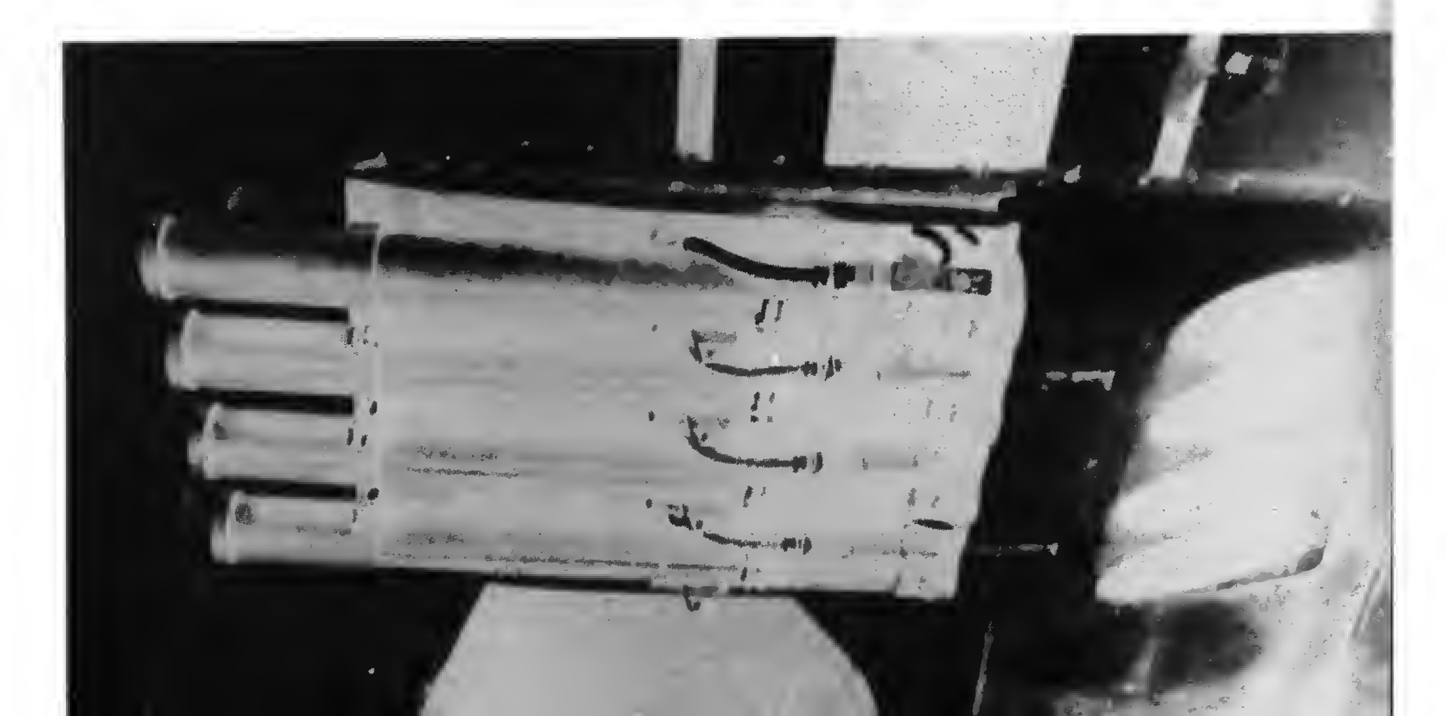


Above: The first trial of a guided droppable weapon conducted by Siemens-Schuckert in 1915.
Center: The Siemens-Schuckert torpedo glider beneath a Zeppelin airship in 1917.
Below: The airship LZ 77 with incendiary rockets, shot down on February 21 1916.

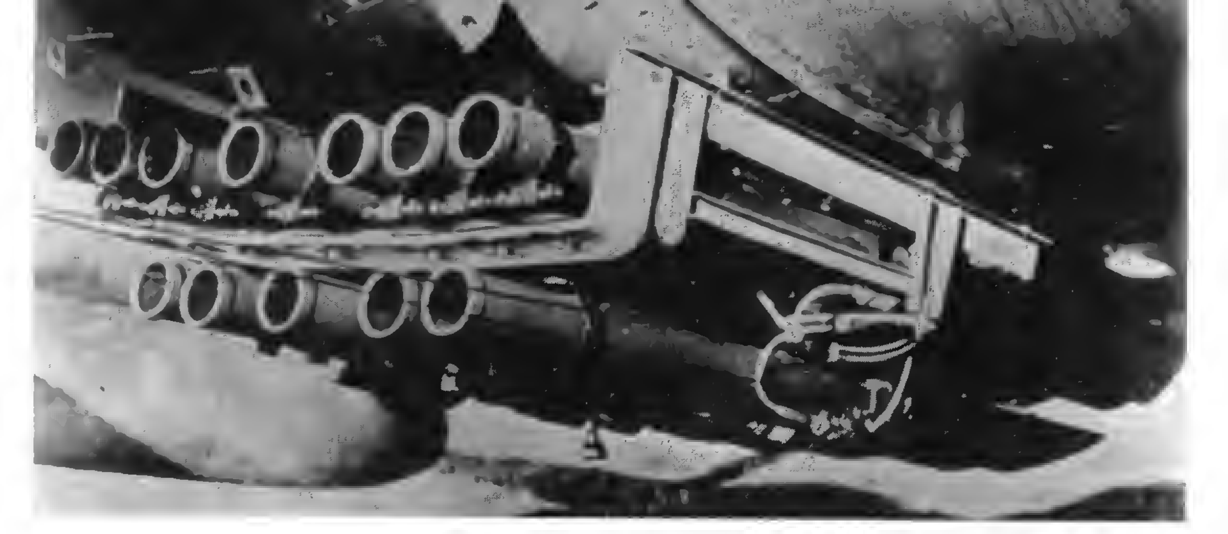
Air-Launched Rockets

Although the firm Rheinmetall-Borsig had conducted tests with spin-stabilized air-launched rockets by 1937, which had been used to hit a 3.6 X 2.6 meter rectangular target from a distance of 100 meters, the development of air-launched rockets was not begun until 1941 under the direction of Dr. Klein. For reasons of secrecy, this developmental series of rockets was designated "RZ = Rauchzylinder," or smoke cylinders. The first development was RZ 65. This was initially planned solely for use against ground targets. For engaging air targets the warhead charge was increased from 130 to 190 grams. Test beds for this series were: the Bf 110 (tail number NE+AC), Bf 110 (BB+AK, He 111 (ND+AU), Ha 137 (NE+AG) and Me 210 V4 (CF+BB). A total of 2,993 RZ 65's were fired in testing. In comparison testing under the exact same conditions, the MG/FF machine guns achieved a 26% hit rate out of 544 rounds fired, while the RZ 65's only achieved a 15% hit rate. Afterwards, there was only a short period of field testing, during which the Fw 190 was also used. The RZ 65's were only used against ground targets. Tests with the *"Trommelgerät (TG)"* firing device for the RZ 65's also proved disappointing.

Above: A Focke-Wulf Fw 190 F-8 with launch grate for two rows of six RZ 65's.



Right: The launching brackets for the RZ 65 under a Bf 109 F-2, factory serial number 9246.





Left: Spin-stabilized air-launched RZ 65.
Above: A Messerschmitt Bf 109 V 19 with twelve firing tubes for the RZ 65.
Below that: A Messerschmitt Bf 109 F-2, serial number 9246 with RZ 65's in two rows of four.

The RZ 73 was supposed to be somewhat of an improvement, but they were utilized only in small numbers. A large series were built by the Schneider KG firm for anti-aircraft missile launchers. A few 158mm RZ 15/8 missiles built by Rheinmetall-Borsig were tested on a Bf 110.

The same firm developed the RZ 100 in 1941 which, due to its larger warhead, had an increased fragmentation effect and therefore a greater chance of hitting ground targets, even if the missile struck slightly off-target. The RZ 100 hat a caliber of 420mm and a weight of 730 kilograms. There was only one ground test performed from under an Me 210 fuselage. The test ended with considerable damage to the fuselage. This signified the end of the spin-stabilized air-launched missile. It was expected that fin-stabilized rockets would prove to be more reliable.



Test firing of the RZ 100: on the left, slung beneath an Me 210 fuselage, above is a side view of the same test, and below, an RZ 100 on the launch ramp during a ground test.





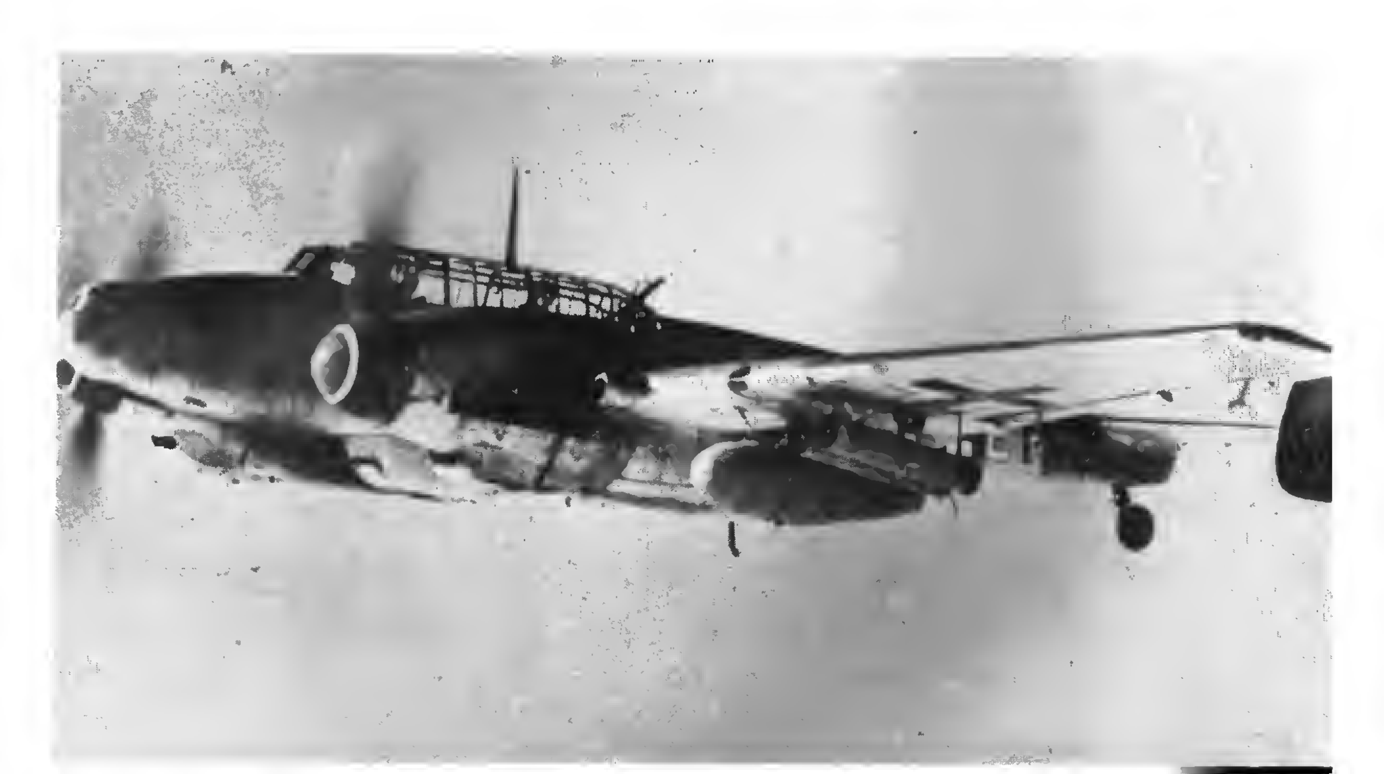
In the meant time, troop units, which were always demanding air launched missiles as a more effective weapon with which to engage enemy bombers from distances outside the range of the enemy aircraft guns, had taken the initiative and used field-expedient methods to help themselves. In so doing, they reverted back to a proven ground weapon, the *Nebelwerfer 41* multiple rocket launcher. This was a weapon consisting of five tubes mounted on a chassis which fired mortar shells weighing 125 kilograms out to ranges up to 7,580 meters. The 28.32cm *Werfer 41* was a heavy weapon, and was soon replaced by the *Werfer 30/42*. The 38cm rocket weighed 83.5 kilograms, its range was 4,500 meters. Then the R 6 series were built for the Fw 190, the R 2 series for the Bf 109 G-6 and the M 5 for the Bf 110, which consisted a



Rocket launcher on the Eastern Front.



Above: A Messerschmitt Bf 109 G-6/R2 with firing tubes for the WGr. 21cm.
Below: A Messerschmitt Bf 110 G-2/R3 with the M5 chassis mounting for the ZG 26.

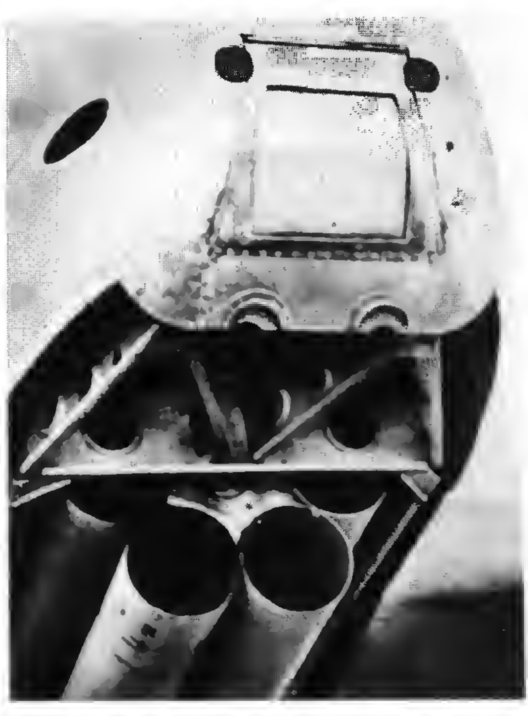


simple brace mounting of a 130cm long tube on the single-seaters and a pair of these tubes on the Bf 110. The tubes were zeroed to a distance of 1,400 meters. The rockets were ignited in their firing tubes by means of an incandescent low-tension electronic detonator, the ERZ 38. The Revi 16 F reflex sight was used for targeting. The first success with these weapons came on August 17th 1943. Of 376 attacking Boeing B-17's of the 8th US-Army Air Force, 60 (16%) were shot down, a large portion of which could be attributed to the 21cm rockets. A still greater success was noted on October 14 1943 when, as on August 17th, the ball-bearing works at Schweinfurt came under attack. This time, of the 291 attacking aircraft, 60 were shot down over Germany, 17 were lost on their return leg and 121 were so heavily damaged that they were considered no longer useable. The bloody losses suffered by the Americans were so high that it caused a crises within the 8th USAAF. This only changed when the Americans could deploy North American P-51 escort fighters, against which the cumbersome German aircraft equipped with the 21cm rocket launchers did not stand a chance.

The initiative for continued development came from the troop units. As an experiment, an Fw 190 F-8 was fitted with the 28/32 grenade launcher for engaging enemy tanks. Only after unofficial tests was the *Flarakete 42* officially reconstructed as the *Jagd 42* missile launcher. In order to be able to deploy more of these same types of weapons at the same time, an Me 410 was fitted with a rotating drum which held six 21cm launch tubes. This was only tested on the ground, however. Other improvement were tested. None of these came into deployment. Toward the end of the war, the Rheinmetall-Borsig



Above: Messerschmitt Me 410 A2 with WGr. drum launcher.



Left: Me 410 A-2 with the drum launcher exposed.



Right: Me 410 A-2 with the drum launcher under its cowling.

A 32cm incendiary rocket beneath an Fw 190 F-8 (contains 50 liters of flammable oil).

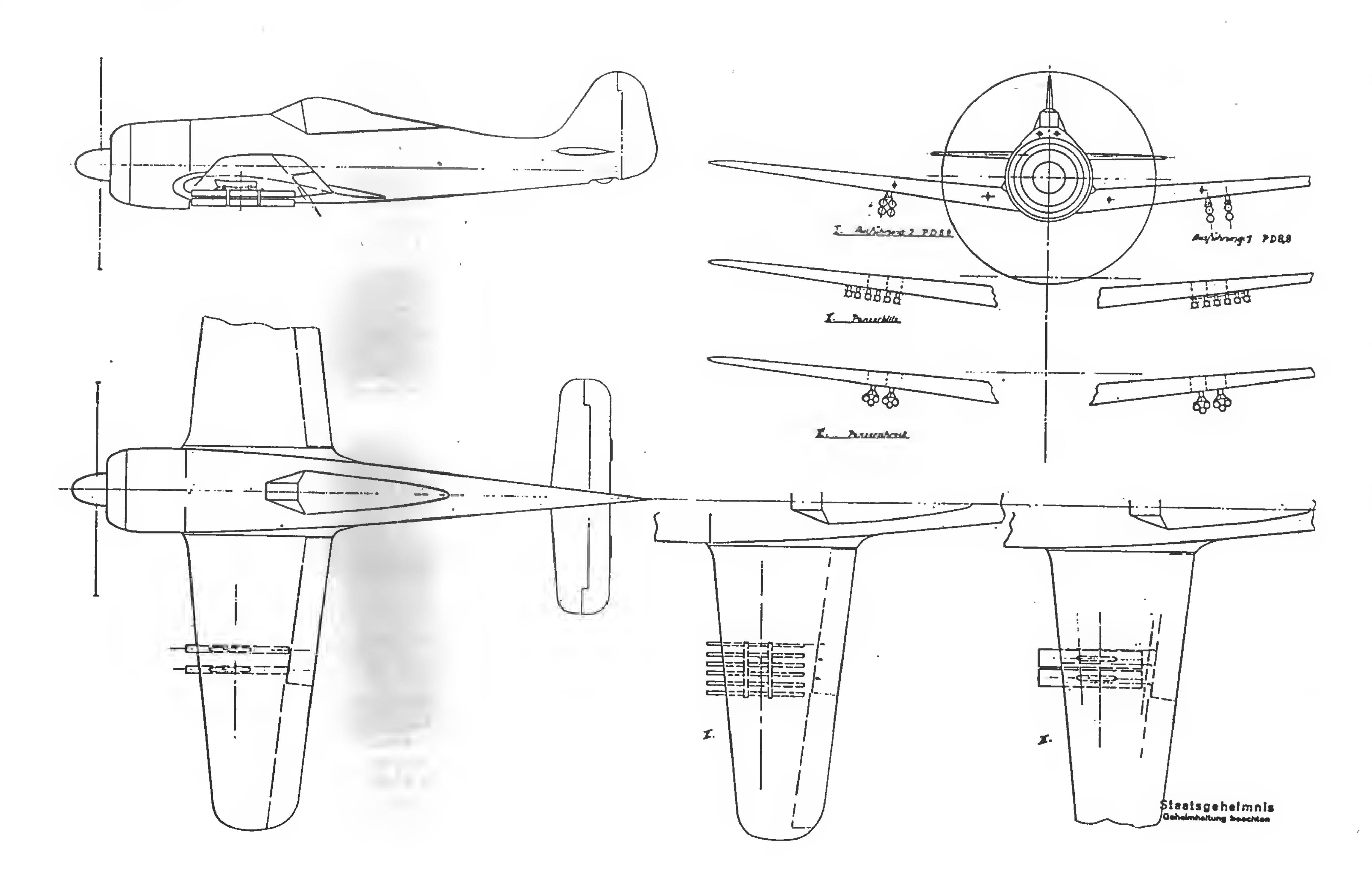


An Fw 190 F-8 with four 8.8cm RPzBGr. 4322's.

firm was continuing to develop the large calibre R 100 air-launched missile in the M, MS and BS versions in its WKL department under the direction of Dr. Lambrich and Dr. Vüllers. The testing could not be concluded.

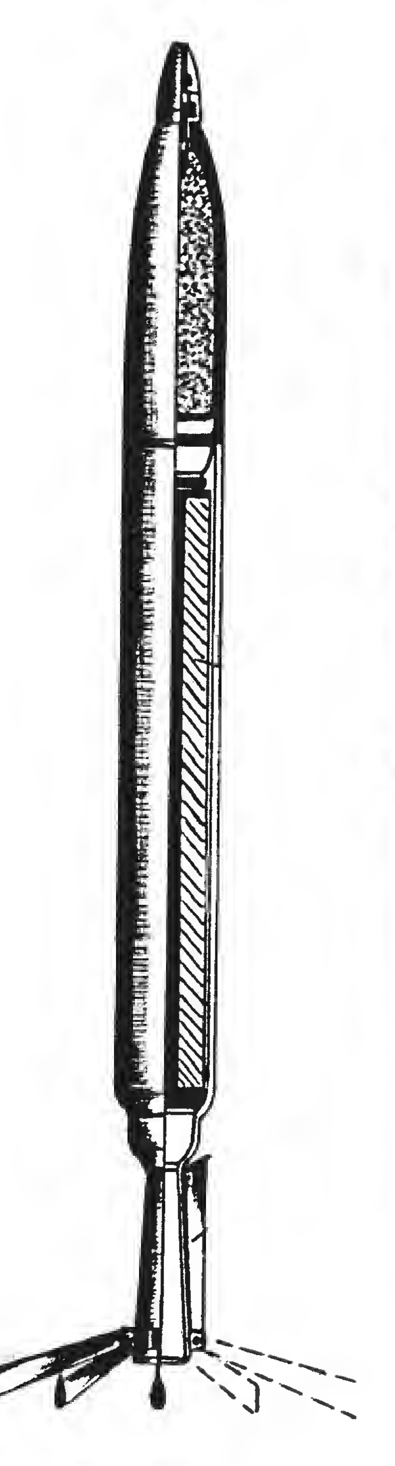
The search for a quickly-produced anti-tank weapon for aircraft lead to the "provisional solution" of the "Flying Tank Terror." This consisted of a re-built infantry weapon modified for use on aircraft. The warhead of this weapon was mated to a casing with a propellant charge which had a ring-shaped fin fastened to it by six braces. The first model had such poor ballistic performance that a second version was made from older army munitions. These were mounted under the wings of the Fw 190 F-8 in rows of four, six and eight rockets by the front-line maintenance shops. The tube of the *Panzerbuchse* anti-tank rocket was utilized on a trial basis. Under the designation "PD 8.8cm Pz. Büchsenrohr", these weapons began to be deployed beginning in October 1944 and formed the basis for the development of the *Panzerblitz I*, for which the 8cm R high-explosive grenade, used by the army, had formed a basis for development. The use of this weapon on a few Fw 190's proved to be a mistake, as the Fw 190 had to descend on its target at a speed of 490km/h which made them easy prey for enemy fighters. The improved "Panzerblitz 2 and 3" did not see deployment.

A truly effective air-launched missile came somewhat too late, as was the case with all the "wonder weapons." It was the fin-stabilized R4/M "Orkan." One man in particular was occupied with the development of this weapon, the same man who had built the first machine gun aiming devices while at Fokker in Schwerin by 1915 and had played a role in the arming of the secret German *Flieger-*


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truppe flying corps during the Versailles Treaty restriction period of 1919-1933. It was Fritz Heber, now chief of the Heber firm in Osterode, who developed the R4/M (R = *Rakete*), 4 = weight of 4 kilograms, M = *Minenkopf*, or mine warhead) together with the German weapons and ammunition plants. A contract was awarded for 20,000 such weapons, of which only 12,000 were delivered. The tests were performed by *Generalmajor* Galland's fighter unit, Jagdverband (JV) 44. By March 1945 at least 50 Me 262 A-1b's had been equipped with 24 R4/M per wing. The success was excellent. On one sortie, 25 aircraft out of 425 B-17 G's were shot down without incurring any losses to German aircraft. In addition to the Me 262, the Me 163 rocket plane was also fitted with the R4/M. The Bachem Ba 349 point defense fighter was supposed to receive a firing system in the nose, a so-called "Bee Hive" consisting of 28 tubes. However, this system caused the nose to explode during testing. An altered version of the Bee Hive, one with 24 tubes, could no longer be tested. The Blohm & Voss Jäger P.212, which was to receive a similar weapon, never became more than a project.

Not until 1942 did the *Reichssluftfahrtministerium* (RLM) begin to think about how they might be able to increase the accuracy of air-launched missiles. In the beginning of that year, Dr. Kramer of the Deutsche Versuchsanstalt für Luftfahrt (DVL) began on the development of an air-launched missile with RLM number GL/C 8-344. The engine for this missile was developed beginning in January 1943 at BMW under RLM number 109-548. The fuel was intended to be a mixture of "Salbeik" and "Tonka 250." Both fuels had various chemical bondings.







Above: Me 262 A-la of the 9./JG7 with R4M firing tubes.

Below: Firing bracket for R4M rockets beneath an Me 262 A-la.

Left: The air-launched R4M.

Electronic guidance was achieved via wire (5,500 meters in length, 0.2mm thick). The pilot guided the device. This weapon was produced by the "Ruhrstahl" firm in Brackwede and the production ran under the designation "X 4 Ruhrstahl." It was equipped with a "Knirps" steering knob which guided the movements of the rocket by sending commands via the FuG 510 "Düsseldorf" radio to the "Detmold" receiver in the missile. If the pilot were to steer the missile so that the its point of light covered the target, then the "Dogge" guidance system was to correct the flight path in the last portion of flight and shadow the evasive actions of the enemy. Then, having been tripped by the engine noise of the enemy plane, the "Meise" detonator would activate at a distance of seven meters igniting a 20kg high-explosive warhead. Because the deliveries of the "Dogge" and "Meise" could not be guaranteed, the entire program was scratched. Test firing had been conducted with Fw 190 V 69 (serial nr. 582079) and Fw 190 F-8's (serial nr.s 583431, 583438 and 584221).

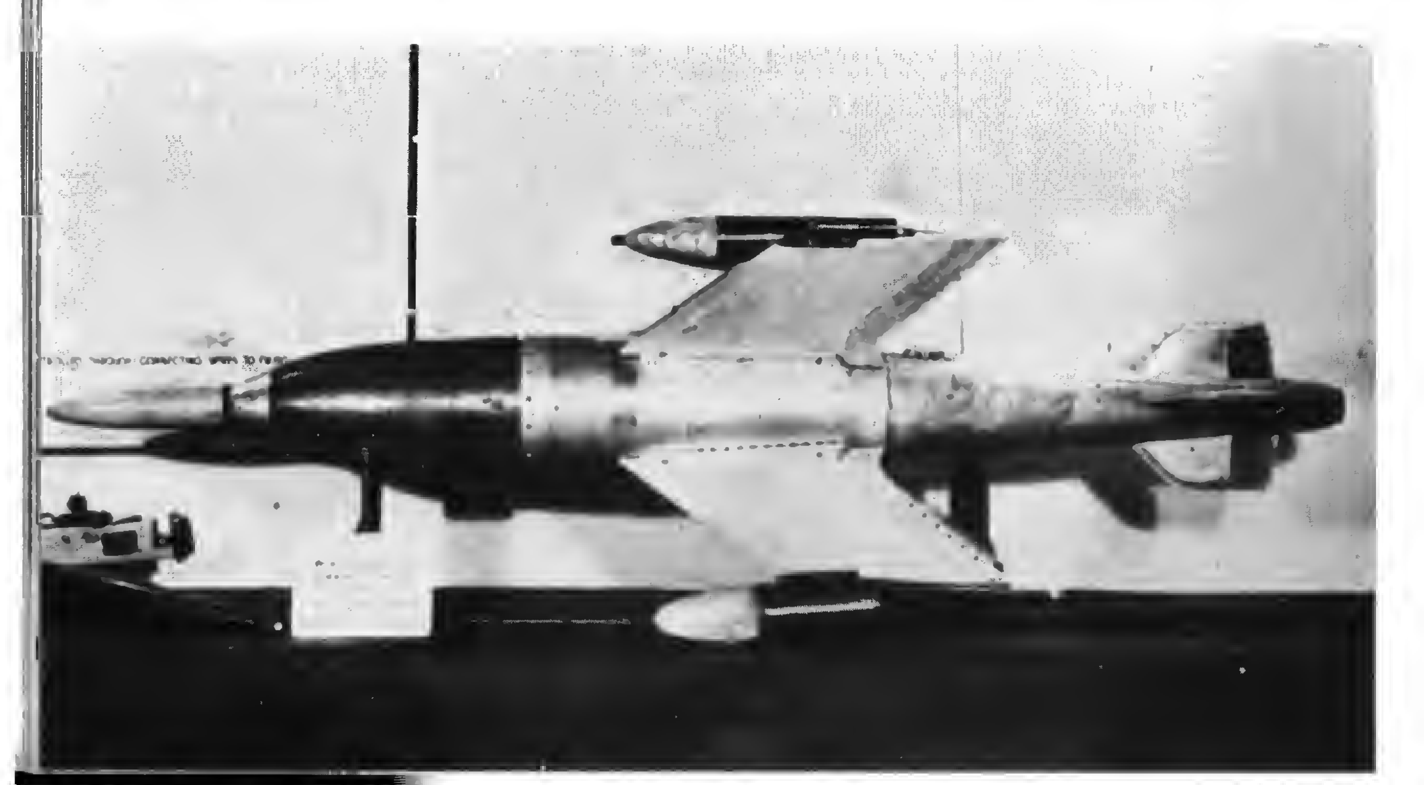
Dr. Kramer began with the development of another fighter missile in 1943 at the DVL. During the course of its development, it was decided to deploy this 2.5kg shaped charge rocket, designated the X 7, as a ground based anti-tank rocket. But this idea was also changed when it was decided to in 1944 to use the X 7 as an air-to-ground missile to engage ground targets. The development was now being conducted under the covername "X 7 Rotkäppchen." The X 7 was similar in appearance to a 15cm mortar shell with wings and a downward-sloping stabilizing tail. It had a solid-fuel engine, the WASAG 109-506. Remote guidance was accomplished via wire, similar to the X 4. Three-hundred of these were built at Ruhrstahl in Brackwede

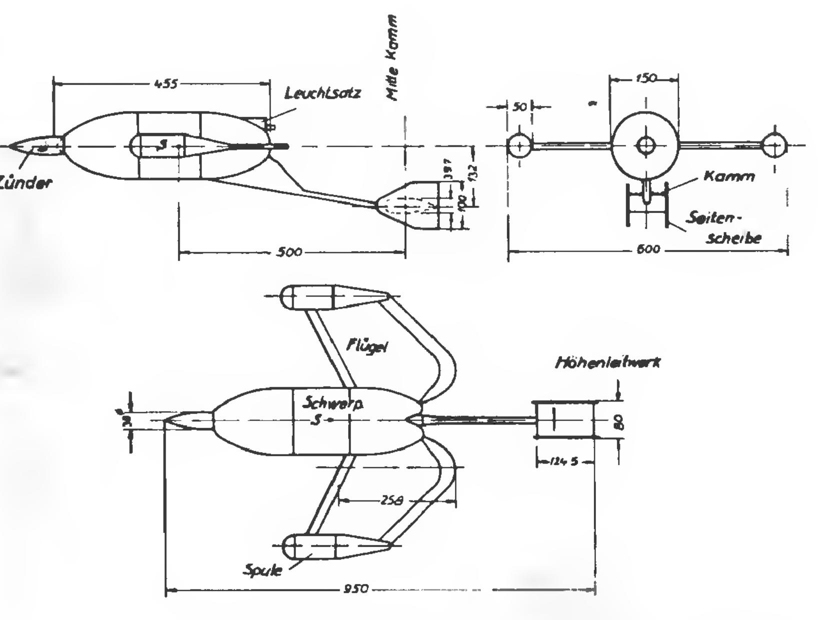


Above: A Bachem Ba 349 "Natter" with 28 R4M's.
Below: The Lippisch Me 163 A armed with R4M's.









and the mechanical works in Neubrandenburg (Fritz Heber, owner). Test firings were conducted with an Fw 190.

The system was never deployed. However, when units retreating from the Russians found large numbers of X 7's in Aladin-Höhle (Aladdin's cave) near Stolberg in the Harz, they managed to use them in one form or another against the allies.

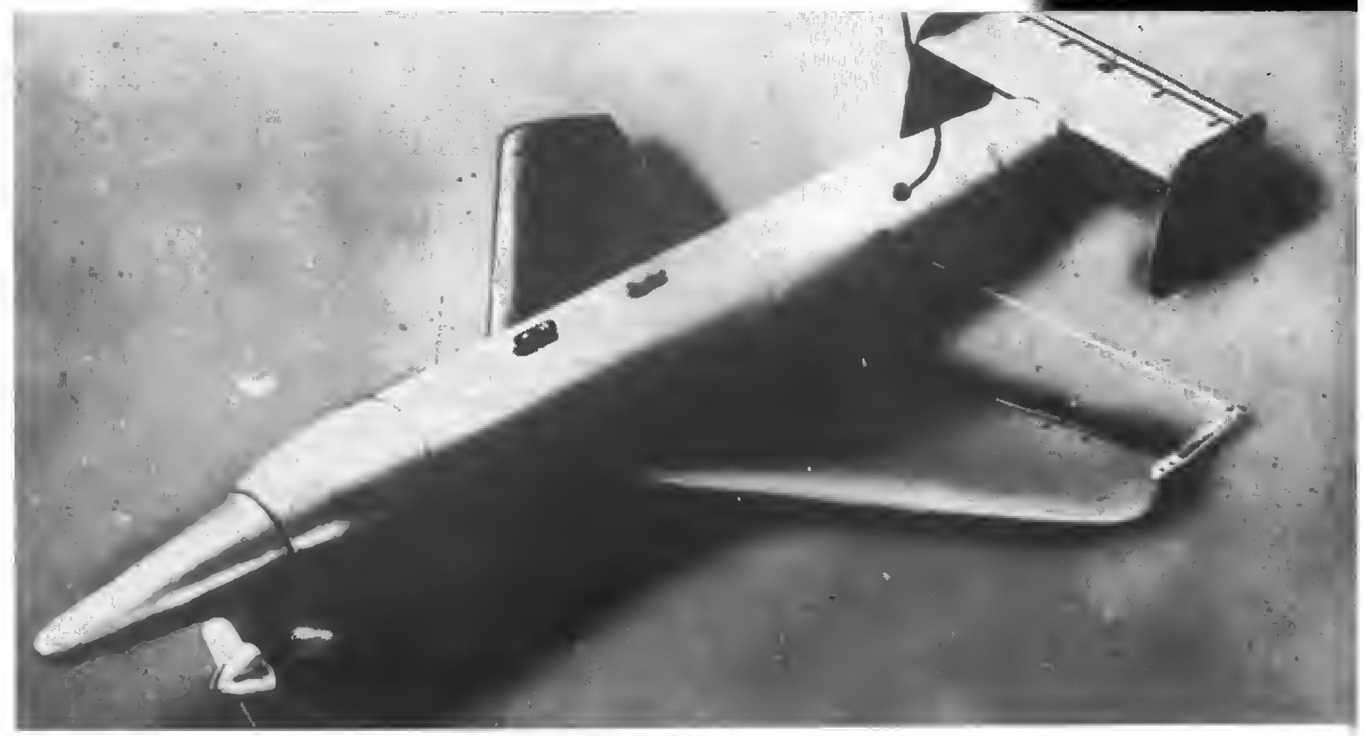
A similar project under the name "Rumpelstilzchen" was underway in 1944/1945 at AEG under the direction of Dr. Kluge. This was under consideration as an anti-tank rocket modified into an air-launched missile. The test series was broken off, however, and the 100 rockets produced for test purposes were only used in the army.

Above left: X 4 fighter rockets beneath an Fw 190 with ETC 70.

Above: The X 7 "Rotkäppchen" fighter missile.

Below left: the X 4 fighter missile with an acoustic fuse.

Anyone who, at the beginning of the war, had the opportunity to travel along the street which led past the western side of the Henschel factory airfield in Schönefeld near Berlin had to have noticed the systems from companies such as Siemens, Askania, Lorenz, AEG and others there on the southern side of the field all occupied in radio guidance work. Night fighters with radio locating systems, high-altitude fighters as well as aircraft with airplane-like devices slung under their wings could all be seen here. This is where, under the direction of Professor Wagner, remotely-controlled rockets, bombs and other missiles were developed. Professor Wagner had already projected a guided missile by 1941, one which the RLM rejected because at that point in time, it was believed the Soviets had been defeated and this type weapon was superfluous. In 1943, however, it was mandated that these missiles go into urgent mass-production, and be conducted at the AEG firm under the direction of Dipl.Ing. Hesky. The planned propulsion unit was a double-chambered Schmidding SG 32 (109-543) using diglycol for fuel. Production ran into difficulties because the proximity fuse which was to be installed in the "snout" in front of the rocket body could not be delivered on time from the Donag firm in Vienna. Not until December 22nd 1944 was a Ju 88 A-4 equipped with launch rails for three Hs 298's, which was the designator for this remotely-guided fighter missile, able to take off. Of the three Hs 298's, only one functioned. Elements of the remote guidance system were to be the FuG 203 "Kehl", the FuG 230 "Strassburg" as well as the FuG 512-FuG530 "Kogge." About 300 were built prior to the Fall of 1944 which were to be utilized by the Do 217 J and N, the Ju 88G-1 and Ju 388 J-1 night fighters. The RLM put a stop to the series, already in production.

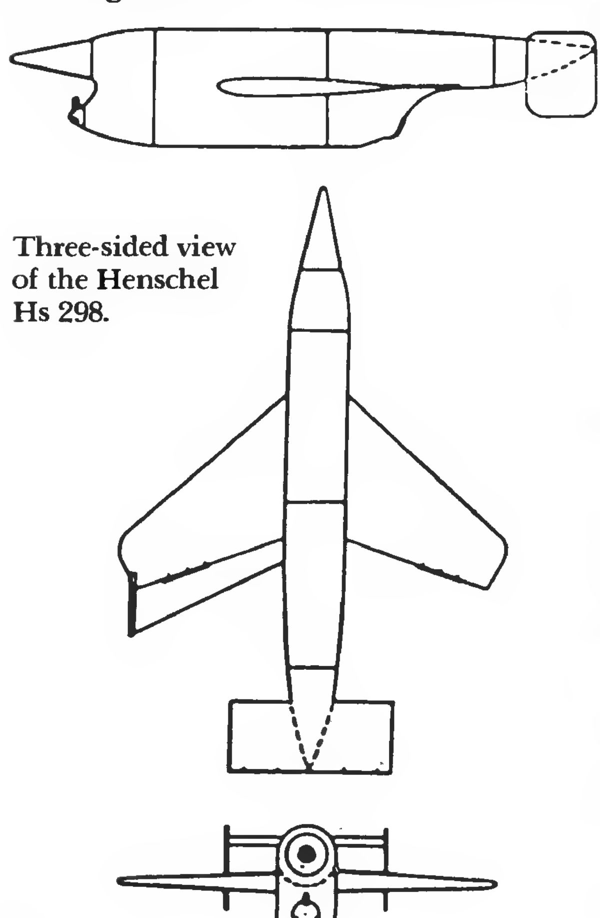


The remotely guided air launched Henschel Hs 298.



The Henschel 298 under a Dornier Do 217.

Henschel proposed a new version, one which came to be the Hs 298 V 2. Of this variant, 135 were built, 100 of which were destroyed in Wansdorf near Berlin when the spearheads of the attacking Soviet Army approached. This marked the end of yet another "wonder weapon." Professor Wagner then proposed the "Zitterrochen" as an air-launched missile, a model of which underwent wind tunnel testing in early 1945 as conducted by Dr. Vöpl at the DVL in Göttingen. There were a few further fighter rocket projects, none of which ever left the drawing board.



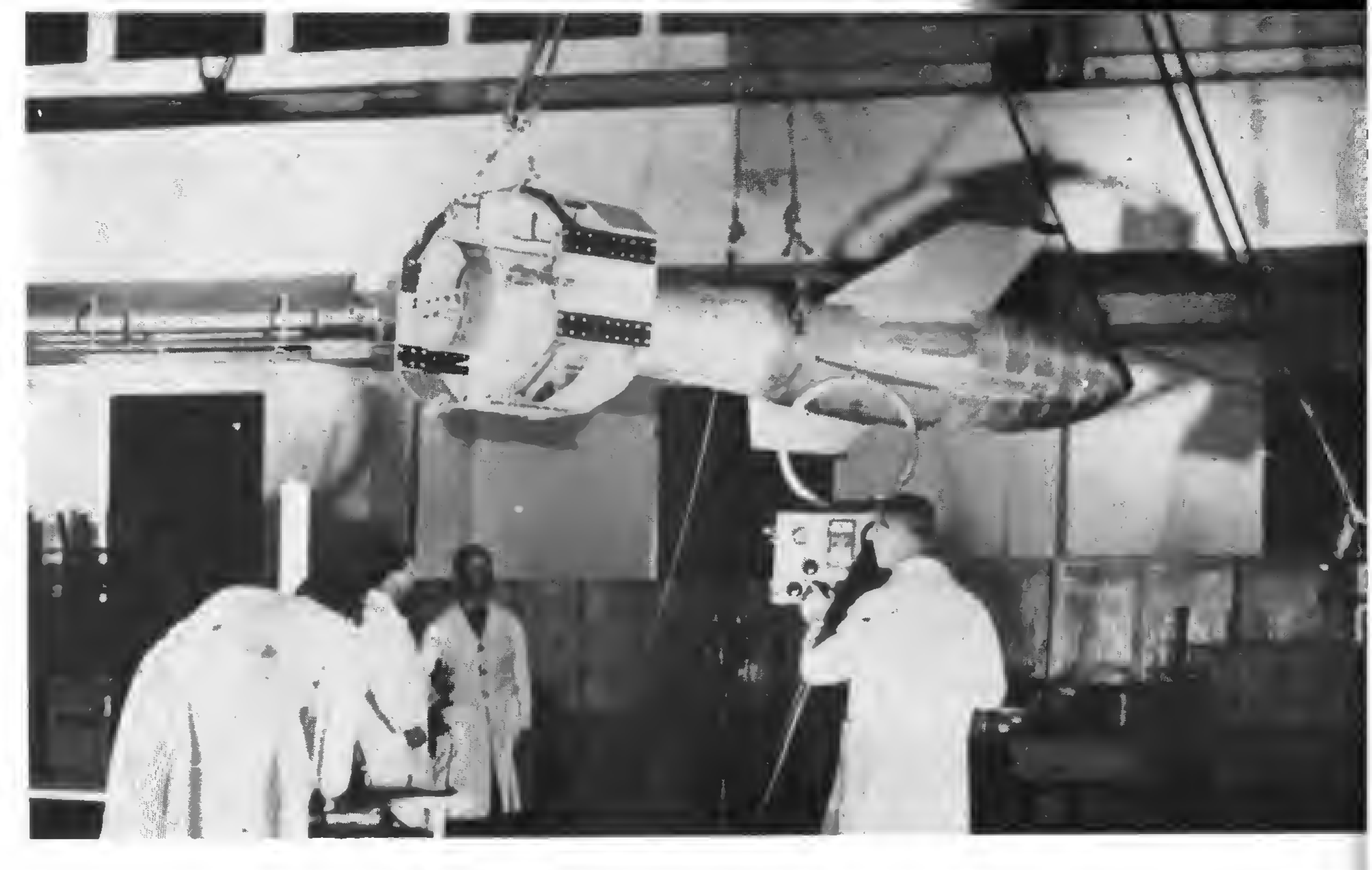
Three-sided view of the Henschel Hs 298.



This Do 217 E-5 (tail number U5+GR) flew at Kampfgeschwader (KG) 2 in 1943, which stood at the ready painted light blue for "special deployments."



Guided Bombs



The PC 1400 "Fritz X" during testing of its guidance system.

Several guidance systems had already been demonstrated on the X 4 and Hs 298 air-launched missiles. Originally, the development of these systems was begun in conjunction with the first attempt to create guided bombs and torpedoes. The inspiration for this development lay in the unsettling lack of accuracy demonstrated by units when making horizontal attacks. The limited range and speed of the Ju 87 dive-bomber showed that they would also not provide a satisfactory answer to the problem. When dropped from horizontal flight as conducted by the Lehrgeschwader (LG) 1 from altitudes of 8-9000 meters on the *Hessen* target ship, only 0.6% were on target.

By 1938, Dr. Max Kramer was working at the DVL on the development of self- and remotely-guided missiles in the X-series, while Prof. H. Wagner was working on the 290-series missiles at the Henschel firm.

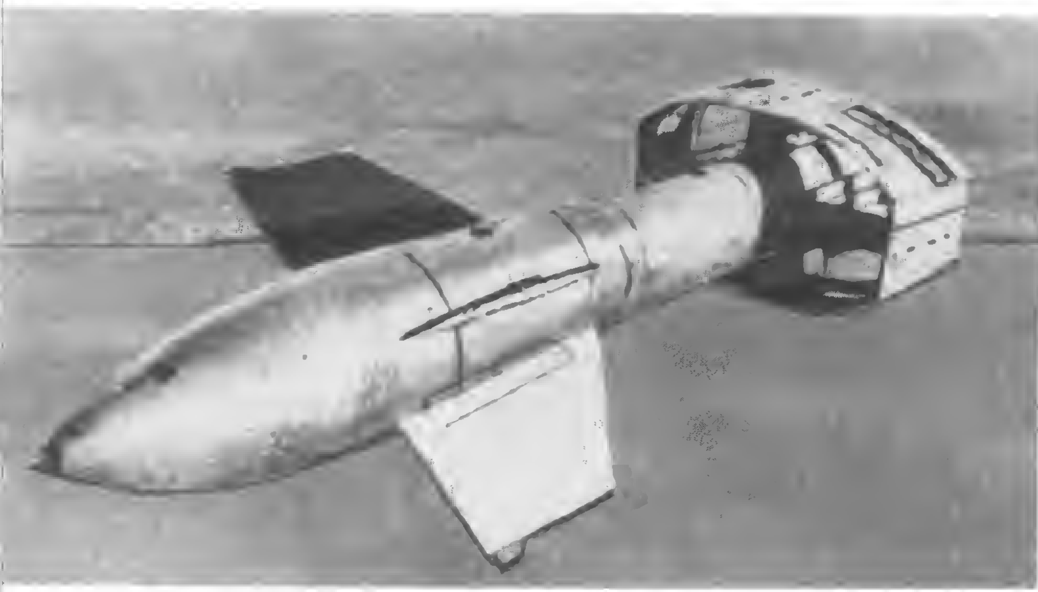
In 1938, the wireless receiver C 192 was created at the *Drahtlos-Luftelektrischen Versuchsanstalt* (an aviation radio research institute) in Gräfelfing based on the results of these efforts, and then in 1940 and improved system was produced, the C 202/203, while the appropriate antenna systems had been developed under the direction of Dr. Zisler at the *Flugfunk-forschungsinstitut Oberpfaffenhofen (FFO)*. The testing which was conducted in the summer of 1940 at the test site in Peenemünde produced no satisfactory results, however, so the devices from the Gräfelfing facility did not enter production.

Other work was conducted on remote control systems under the utmost secrecy. This work was performed by the DVL, the DVG as well as the Telefunken, Lorenz, Siemens, Loewe-Opta and other firms, as each party only worked on solving one portion of the equation so that no one had an overview of the entire program. At the end of January 1940, a large remote control conference for all developers was held at the Stassfurter Rundfunk GmbH, which resulted in the "Kehl-Strassburg" program for the development of the Pc 1400 X (Fritz X) and the Hs 293 guided bombs. The radio transmitter system FuG 203 was called "Kehl" and the FuG 230 radio receiver system was known as the "Strassburg" device. There were six versions of the FuG 203 and three versions of the FuG 230. All systems were intended for the guidance of the "Fritz X" and Hs 293 guided bombs.

As early as 1938, Dr. Max Kramer of the DVL had conducted tests with an SC 250 bomb and a box-shaped tail assembly. These tests were so successful that Rheinmetall-Borsig in Berlin Marienfelde was put under contract for further development based on the PC 1400 bomb. A circular shaped tail section weighing approximately 120 kilograms was fastened to the bomb and housed two gyroscopes and the necessary gear for radio guidance, together with the battery and transformer and was carried on the end of the box-like empennage. Additionally, the bomb's fuselage was fitted with X-wings mounted at angles of +/- 28 degrees. This weapon, called the PC 1400 X = Fritz X, was



The "Fritz X" guided bomb beneath a Heinkel He 111 H-6.



A "Fritz X" in freefall just after release.

especially intended for attacking heavily armored ships. In early 1943, the III./KG 100, which had Dornier Do 217 K-2's, K-3's and M-2's, were equipped with "Kehl III" guidance device for dropping the Fritz X.

Somewhat later the III./KG 40 equipped with Fw 200 C-6's and C-8's and the II./KG 40 equipped with He 177 A-3's and A-5's and the "Kehl IV" were added to this. This device could be utilized selectively for dropping either the "Fritz X" or the Hs 293.

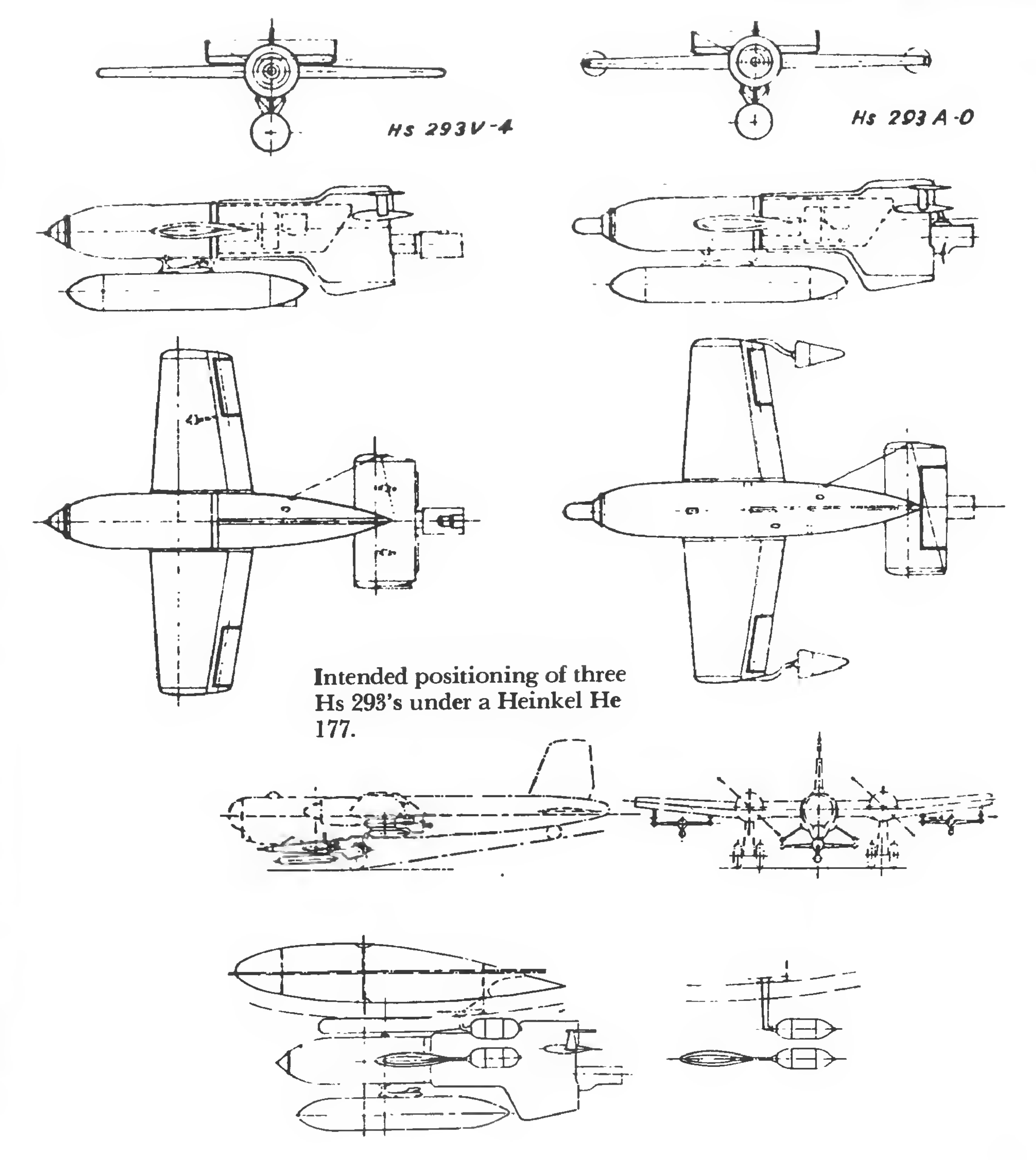
The first deployments met with no success. However, on September 9th 1943 III./KG 100 managed to sink the Italian battleship "Roma" with a "Fritz X" and heavily damage the "Italia." One the same day, the allies landed at Salerno where in the following days the US Cruiser "Savannah" and a few destroyers received hits. On September 16th, three Do 217 K-3's of the III./KG 100 attacked the british battleship "Warspite" at Salerno and damaged it so heavily that it had to be towed to Malta and was out of action for six months. When the allies conquered Foggia on 27 September, where the German airfield responsible for the Mediterranean theatre was located, they captured "Fritz X" and Hs 293 bombs still in their crating, a fact which was not known to the German side. Between the 13th and 22nd of June 1044 (during the allied invasion), the "Fritz X" was able to achieve a few more small successes. On August 7th a Do 217 of II./KG 40 succeeded in destroying the bridge at Pontaubault with a "Fritz X" after two attacks had failed. As a result, the advance of the Sixth US Tank Division could be stopped for a short time. When the allies landed in southern France on August 15th, a few desperate attacks were flown until only a few aircraft remained in flyable condition. On 22 August 1944, 15 He 177's which had been restored to flying condition were demolished because their crews were stuck in Strassburg due to lack of

transportation. This was the end of the "Fritz X."

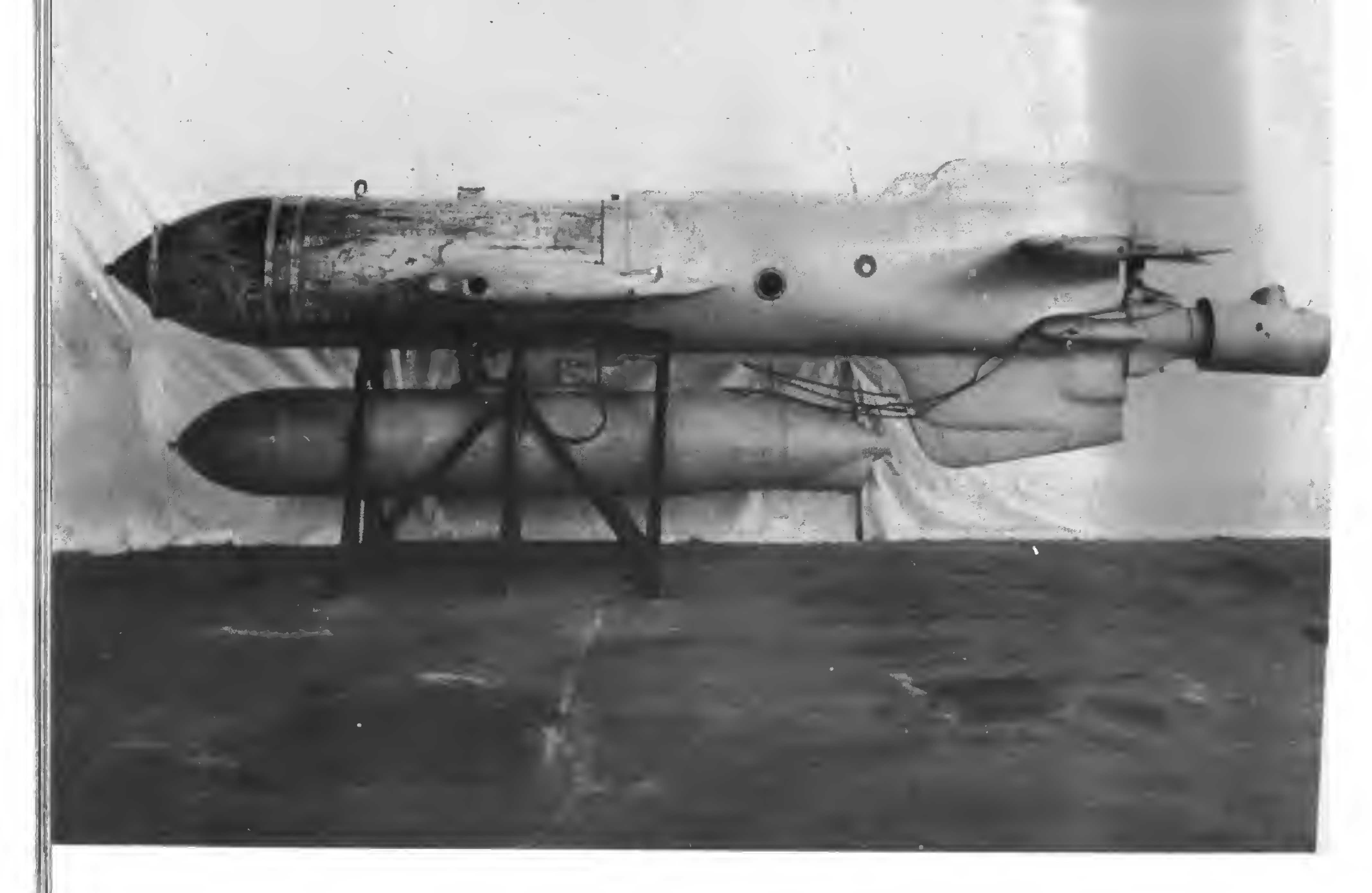
The Henschel firm at Schönefeld near Berlin (at the time of writing the airport of the GDR's airline INTERFLUG) Prof. Wagner worked on a flying bomb based on an SC 500 bomb. The first successful tests were conducted with an Hs 293 V 2 model, the first unguided drop on September 5 1940, the first guided drop with model W 12 on December 16 1940. Model W 13 was a complete success only two days later and became the initial model for the first Hs 293 A-0 series. In early 1941, the Luftwaffe's E-4 test facility at Peenemünde conducted a test during which a large target ship struck from a distance of 7,500 meters.

The Hs 293 A-0 began mass production in November 1941. It was followed in January 1942 by the Hs 293 A-1, of which about 1,250 were built. These guided bombs used the HWK 109-507B rocket engine for propulsion. The Heinkel He 111 H-12 was the aircraft which carried this weapon. Guidance was achieved via the "Kehl III" and FuG 230b "Strassburg." The first deployment occurred on August 25 1943 during which 12 Do 217's of KG 100 operated against enemy submarine hunters in the Gulf of Biscaya. On September 30 1943, eleven Do 217's attacked the Ajaccio harbor on Corsica. Seven aircraft were lost in the attack. The worst was, however, that two Hs 293's glided onto the harbor waterfront and were re-constructed by the enemy.

Due to errors in production, there were numerous failures. Nevertheless, Fw 200's and He 177's of the II. and III./KG 40 still flew numerous successful missions which resulted in a 28% dud rate and a 31% hit rate. II./KG 100 was able to achieve a 25% dud rate and a 55% hit rate.



Intended positioning of three Hs 293's under a Heinkel He 177.



Besides the "Fritz X," the Henschel Hs 293 was the only guided bomb to see use at the front.

In order to avoid eventual disruption to radio guidance, the Hs 293 B was created in 1944, of which 200 were built. This was wire-guided. The wires were twelve kilometers long. The FuG 207 "Dortmund" (a transmitter) and the FuGz237 "Duisburg" (a receiver) were the guidance system. A second model had 16-kilometer wires. Attempts to jam them by the allies in early 1944 were only marginally successful. A weapon very similar to the Hs 293 B was built and tested in the summer of 1958 in Argentina.

About 60 Hs 293 C's were developed as underwater bombs, which were produced in various models and were intended to strike ships below the water line. They were not deployed. The Hs 293 C can be considered the predecessor to the Hs 294.

The Hs 293 D was the first guided bomb to be fitted with a television camera, which was intended to enable the bomb to hide in the clouds to avoid anti-aircraft defenses. The first unsuccessful attempts were conducted in the Fall of 1943 at Madüsee, near Stargard in Pommern. Other attempts at Jesau in Ostpreussen were not successful. The best results were obtained in the middle of August 1944 with a new guidance system combination of the "Tonne 4a" and "Seedorf 3" with which one direct hit and a few near misses were achieved out of five drops. As a result, a new research contract was awarded in October 1944 which was intended to result in a perfected guided bomb equipped with television guidance. Two hundred and fifty-five were produce which, however, were not deployed.

Only 18 Hs 293 E's of the developed and improved C model were produced before the program was deleted. Project Hs 293 F, which was supposed to be a delta-wing model, was abandoned at the end of 1943. An Hs 293 G was to be used to attack targets like a dive bomber. Ten test models were built.



Above: The FuG 203 "Kehl III" guidance system in an He 111 H-18.
Below: A Focke-Wulf Fw 200 C-4 with two Hs 293's.





A Dornier Do 217 E-5 of 6./KG 100, tail number 6N+HP, with an Hs 293 V 4.

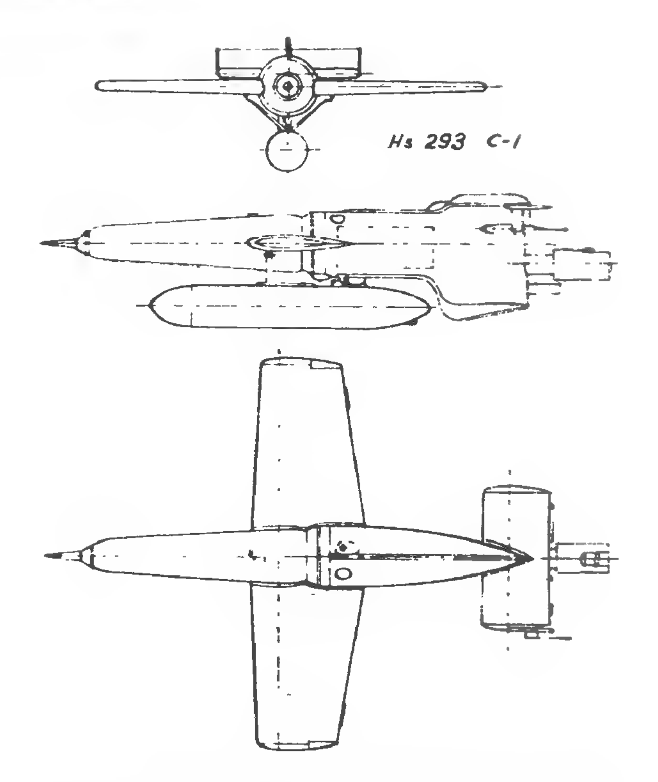
Development was broken off, however, due to complex target homing guidance.

After it had been attempted to guide the Hs 293 A into US bomber formations, a new draft of the Hs 293 H was proposed to the RLM, the chief difference between it and the A-version being the E-230 H/I receiver and the twin engine configuration, which were planned to be either the 109-543 or the Schmidding 109-513 engines. In 1943, eight test models were built which were dropped about 600 to 2000 meters above the enemy formation at a distance of 1,000 to 3,500 meters and were steered into the formation by means of the target congruent homing method. Dr. Born of the *Deutsche Forschungsanstalt für Segelflug (DFS)* (German Glider Research Institute) worked on an acoustic trigger and guidance system for the Hs 293 H. The research could not be concluded.

The last version of the Hs 293 series was the Hs 293 I. This was an Hs 293 A with a larger warhead (500 kilograms of explosive). Of few test models were actually built, but this model never saw action.

As early as 1941, plans were in the works to build a steerable Hs 294 torpedo bomb. Using the Hs 293 C as a basis, a gliding bomb was constructed whose increased weight made it necessary to use two 109-507D engines. Among those built were the 20 Hs 294 V1's, 40 to 80 Hs 294 A-0's, 45 Hs 294 V2's, a few additional test models and 20 Hs 204 D's with television guidance. The He 177 and Ju 290 were intended to be the aircraft to carry them. But because neither type met the requirements, the development of the Hs 294 had to be stopped.

Further development of the Hs 293 I in 1942 was planned as the Hs 295. About 50 test



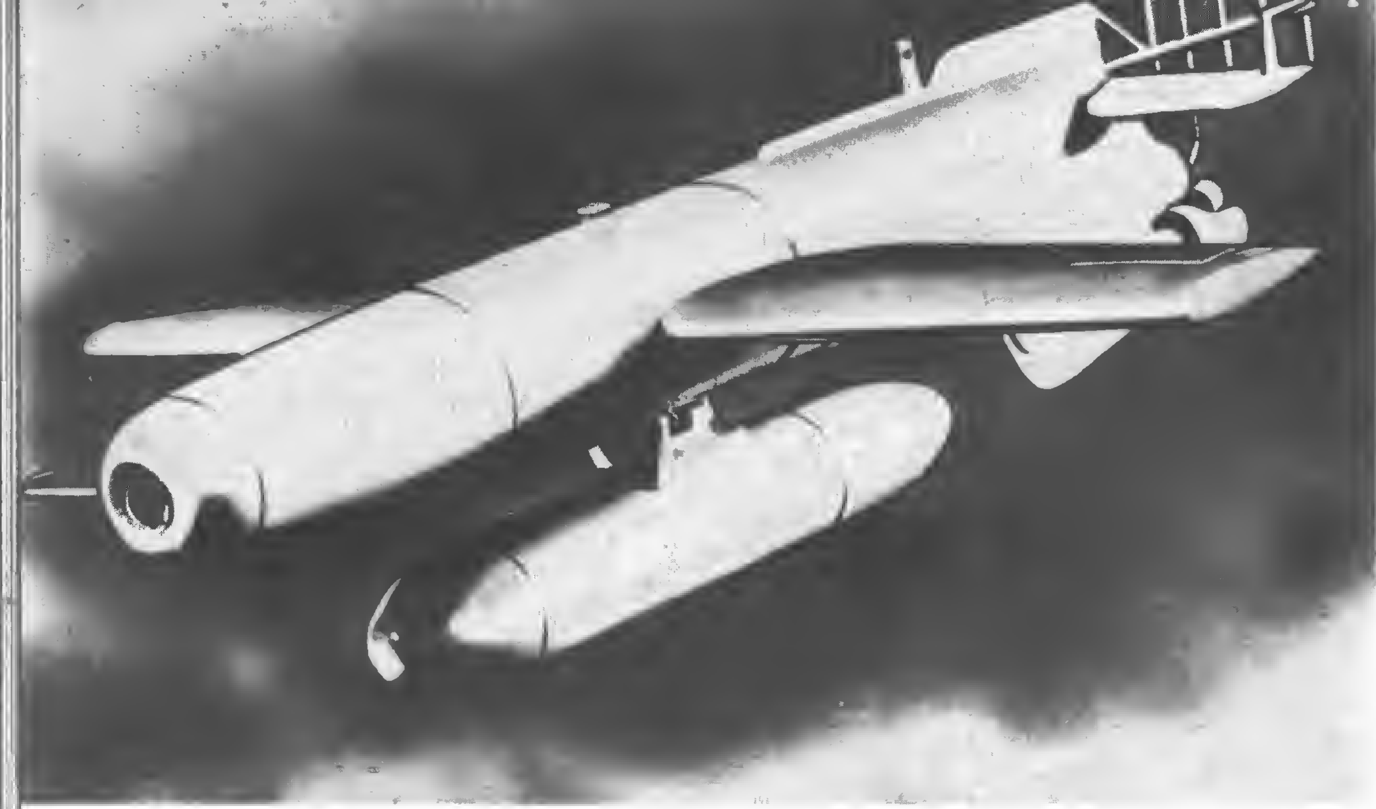
Hs 293 C-3

Hs 293 C-4

models were produced, but this development also had to be halted due to a lack of aircraft capable of carrying them.

The Hs 296 was externally similar to it predecessors, but was to be utilized as a combination gliding/diving bomb. A few test models were built. But because only one test model of the Me 262 aircraft which was to carry it was built, this development also reached a dead end. A project under the name "Peter X" was proposed on June 23rd 1943 as a replacement for the "Fritz X" gliding bomb. Four versions of this were proposed, which were to weigh between 1,775 and 1,943 kilograms. This project went on file at the RLM with the remark, "... production is to be accelerated by all available means to match the Hs 294 for use against armored targets." The fate of the Hs 294 was already determined.

Left: A three sided view of the Henschel Hs 293 C-1, C-3, C-4 and the Hs 293H with rod-type antenna for the proximity fuse.

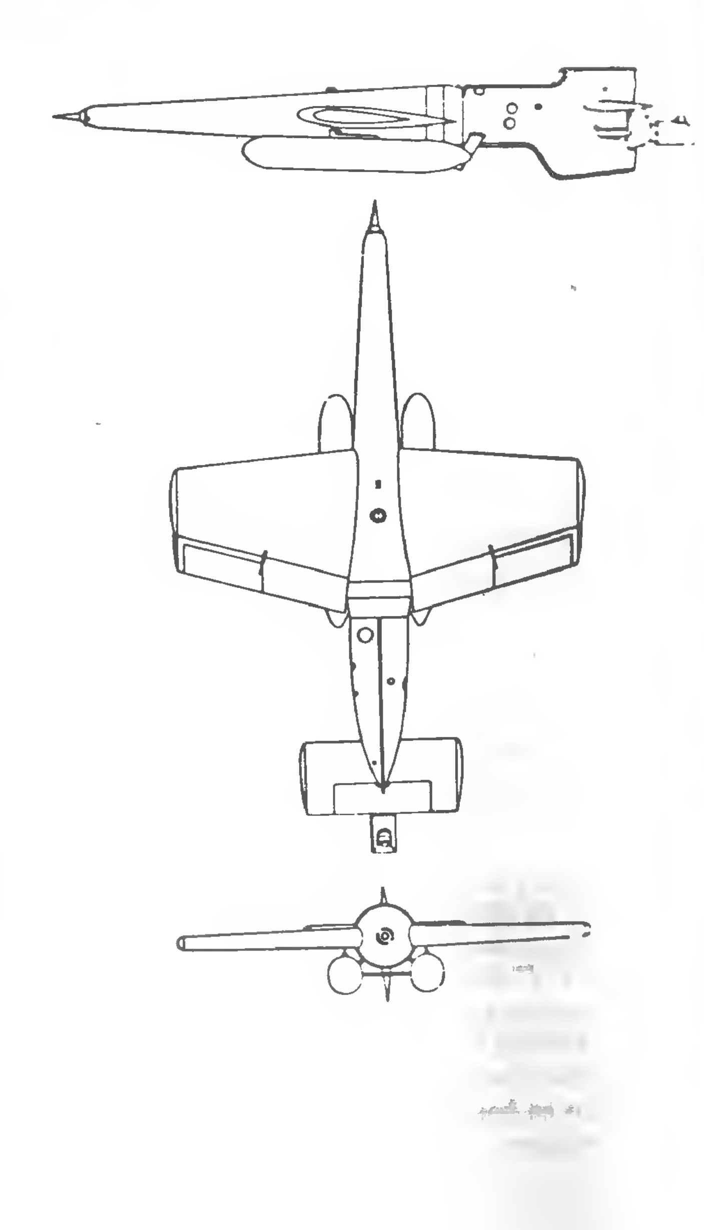


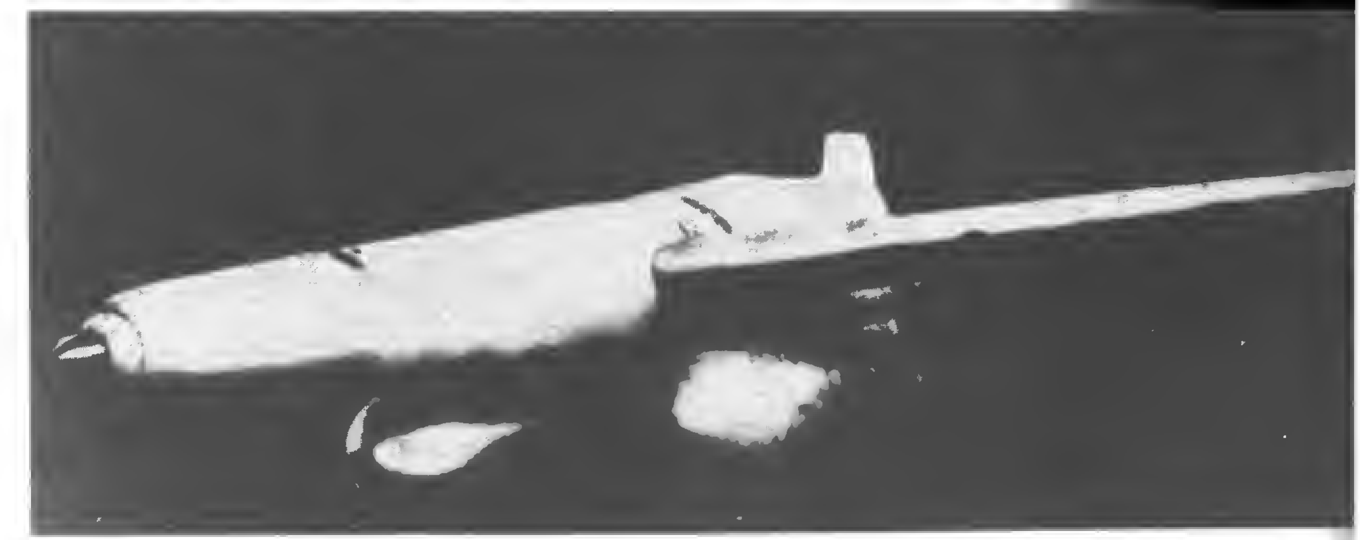


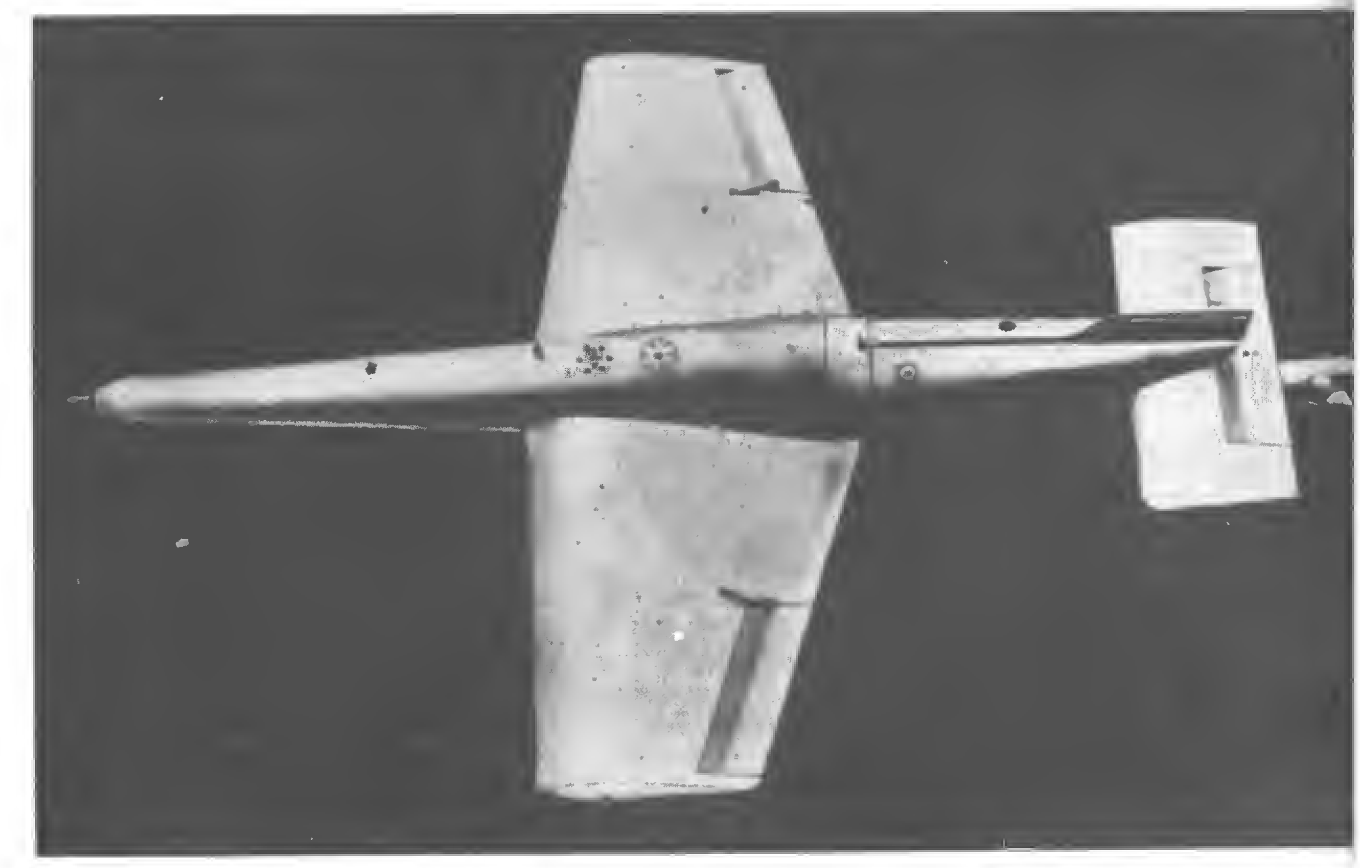

Above and right, the Henschel Hs 293 D.

By 1938 the DFS, section A-1, had received the contract calling for the development of a gliding bomb which would weight approximately 500 kilograms and would have a glide ratio of 1:5 and was to reach a terminal velocity of 360km/h. Two developmental versions were hammered out at the DFS, which were examined by Dipl.Ing.'s Muttray and Feder. There were six drafts with various square wing shapes, as well as others with flying wing shapes. There were versions with circular tail sections, as well as the "Seehund," "Hecht" and "Tandem" models. With the exception of a few test models, none of these projects became reality. Prof. Lippisch developed the GB 3/L gliding bomb from his Delta-Jäger projects. The concept was first proposed in 1944, but was not pursued due to Lippisch's other projects.

Dr. Richard Vogt, the technical director at Blohm & Voss, was busy with different approaches. As a replacement for the V 1 (FGZ 76/Fi 103), he suggested a long-range gliding bomb which was to be carried by the He 111 H and Ju 88 A-4 aircraft, which, it was hoped, would be able to carry three of these weapons at a time. The ETC 2000 was planned as the load carrier. This device, first called the Bv 226 and later the Bv 246 "Hagelkorn," was supposed to be dropped from an altitude of 7,000 meters at a speed of 550 km/h and reach a range of 210 kilometers which would permit the speed of the bomb to slow to 450 km/h near the ground. Because initial tests did not show encouraging accuracy results, which were worse than the V 1, RLM turned down this project. On July 2nd 1943 the test facility at Karlshagen received a contract to test for the Bv 246 B. Field testing was to be conducted by KG 101 at Greifswald.

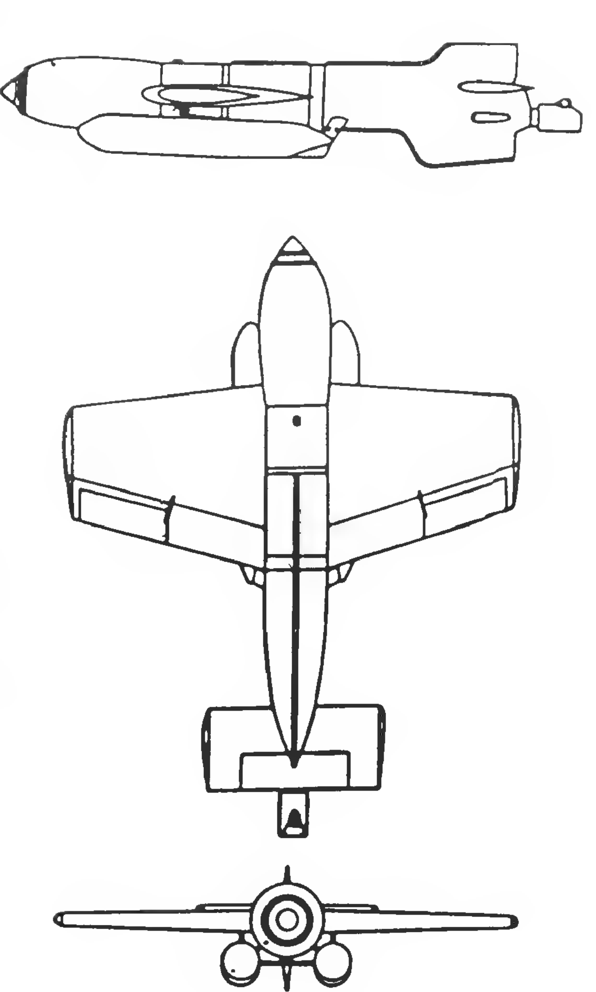








Photos from two perspectives and a three-sided view of the Henschel Hs 294.



Two photos and a three-sided drawing of the Henschel Hs 295.

Testing was conducted with a Ju 188 E-1, factory serial number 26093, but no satisfactory results were noted. The glide ration and accuracy did not meet the initial requirements. When the carrier aircraft broke down, the testing came to a standstill. Despite this, a mass-production contract was awarded on December 12 1943, but was already stopped by February 26 1944. Based on new recommendations, testing was resumed on March 8 1944, however was stopped again due to greatly reduced targeting accuracy. Only a small series of 550 Bv 246 B's were produced as anti-aircraft gunnery targets. Between July 3 1943 and July 5 1944, 238 Bv 246's were tested with various guidance systems, during which the Ju 88 A-4, an He 111 H-6 and an Fw 190 A-6 served as carrier aircraft. On July 5 1944, KG 101 tested 50 Bv 246's but one day later everything, with the exception of the anti-aircraft targets, came to a halt.

The 29 Bv 246's on hand in Karlshagen were destroyed on July 17th in an aerial attack. On August 14 1944 all version of the Bv 246 were released for testing and a new test facility in Fassberg near Celle was planned. There were a total of almost 1,100 Bv 246's produced, of which 599 were still on hand on January 1 1945. Although the He 111 H-6 with an FuG 103 installed as an altimeter, with two Bv 246's combed to an altitude of 7,000 meters in 45 minutes, and the Arado Ar 234 and the Me 262 were planned as other missile carriers, the testing at the troop units could not ever be concluded.



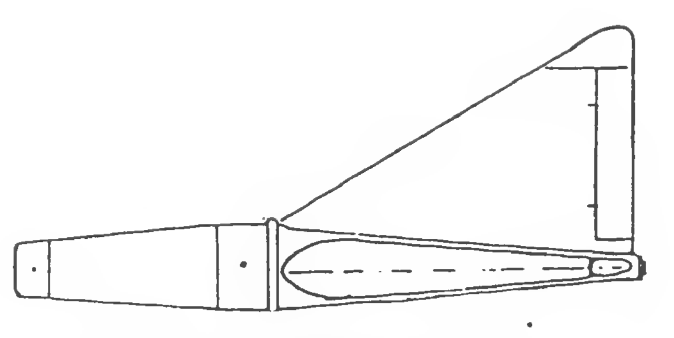
Above: The first version of the long-range gliding bomb, the Blohm & Voss Bv 226 (246).

Right: Mass production of the Blohm & Voss Bv 246 "Hagelkorn" long-range gliding bomb.

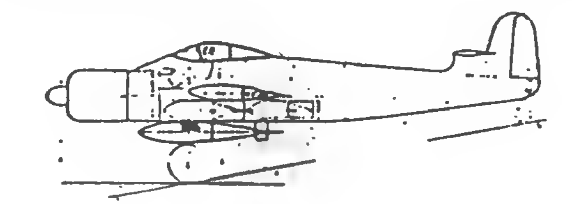
Three-sided view of the Blohm & Voss Bv 246.

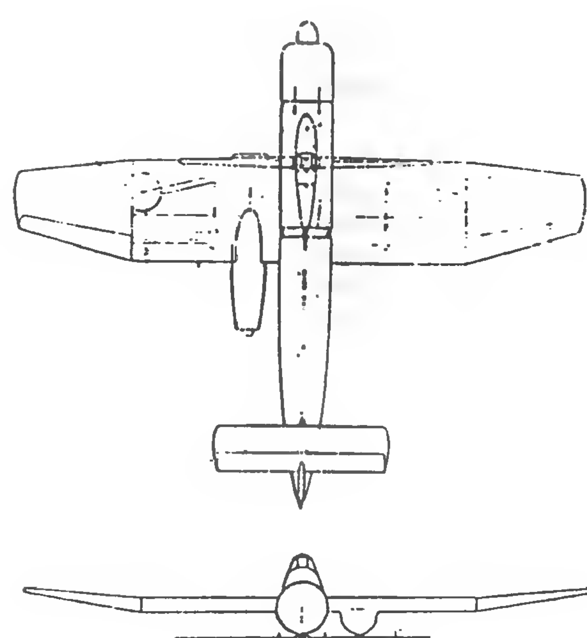
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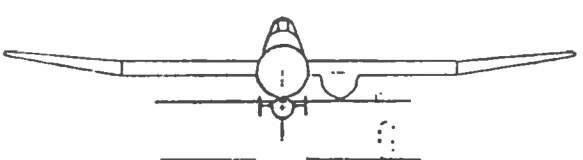
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Side view of the Lippisch GB 3/L gliding bomb project.







Plans of the Blohm & Voss P.204 with a Bv 246.

A Heinkel He 111 H-6 with three Bv 246's.



A Focke-Wulf Fw 190 F-8 with a Bv 246.

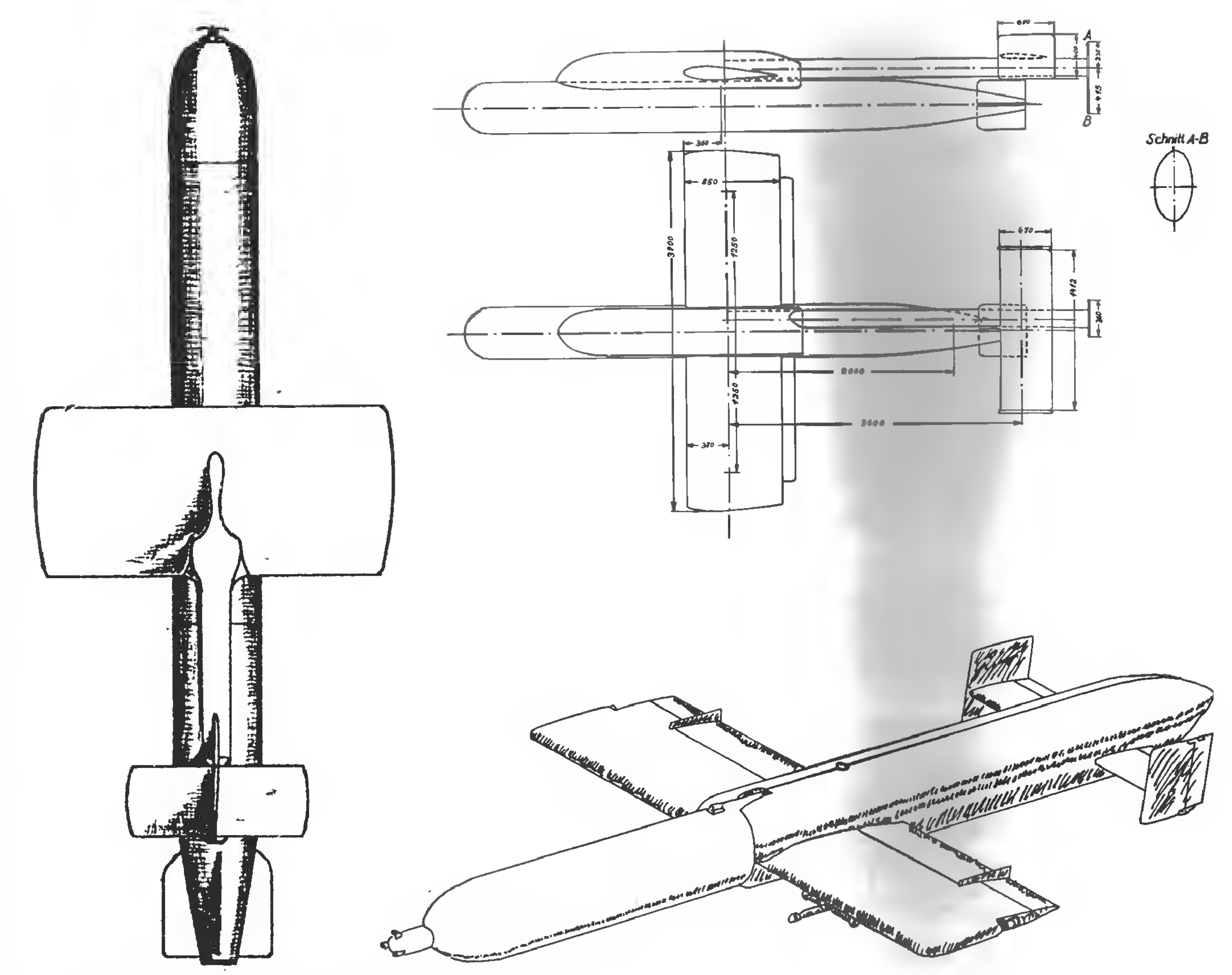


During testing, the Fw 190 proved itself to be particularly suited for the deployment of this weapon.

Gliding Torpedoes and Torpedo Gliders

In October 1940 a torpedo LT 5 F with wings and a tail section was tested in the wind tunnel at the Deutsche Versuchsanstalt für Luftfahrt (DVL). Afterwards, plans were made for the DT 1 and 2 gliding torpedoes. Instead, a gliding torpedo called the LT 9.2 "Frosch" (frog) was developed at the Luftfahrt-Forschungsanstalt at Braunschweig-Völkenrode, which was later abandoned in favor of the Blohm & Voss L 10 "Friedensengel" (angel of peace). This was a torpedo carrier which would permit the torpedo to be launched at greater distances than the LT 950 C. This glider was to be dropped from an altitude of 2,500 meters and have a range of 8,500 meters. Only three seconds after launch, a small kite was deployed from a container under the left wing which was towed along on a 25 meter cable. When the L 10 was about ten meters above the surface of the water, the kite sensed this and sent an electronic signal via a forward-mounted membrane to set off the explosive bolts which held the LT to the L 10. The LT released from the L 10 and took an underwater trajectory in route to its target. Fifty-four of these were manufactured, which were used during test drops beginning in September 1942.

Afterwards, 330 were planned for production in various forms, of which 270 were actually built. Of those, 136 were used in testing, and 34 were delivered to KG 26 for field testing. On December 21st 1943, test weapon subject number 58 was dropped from an He 111 H-6, tail number ND+AS, from an altitude of 428 meters at a speed of 281 km/h and, with a glide angle of 16 degrees, covered a distance of 1,448 meters in a flight time of 18.9 seconds. Another He 111, tail number PB+PJ, was able to achieve a range of 3,276 meters with a different test weapon.



The LT 9.2 "Frosch" gliding torpedo.

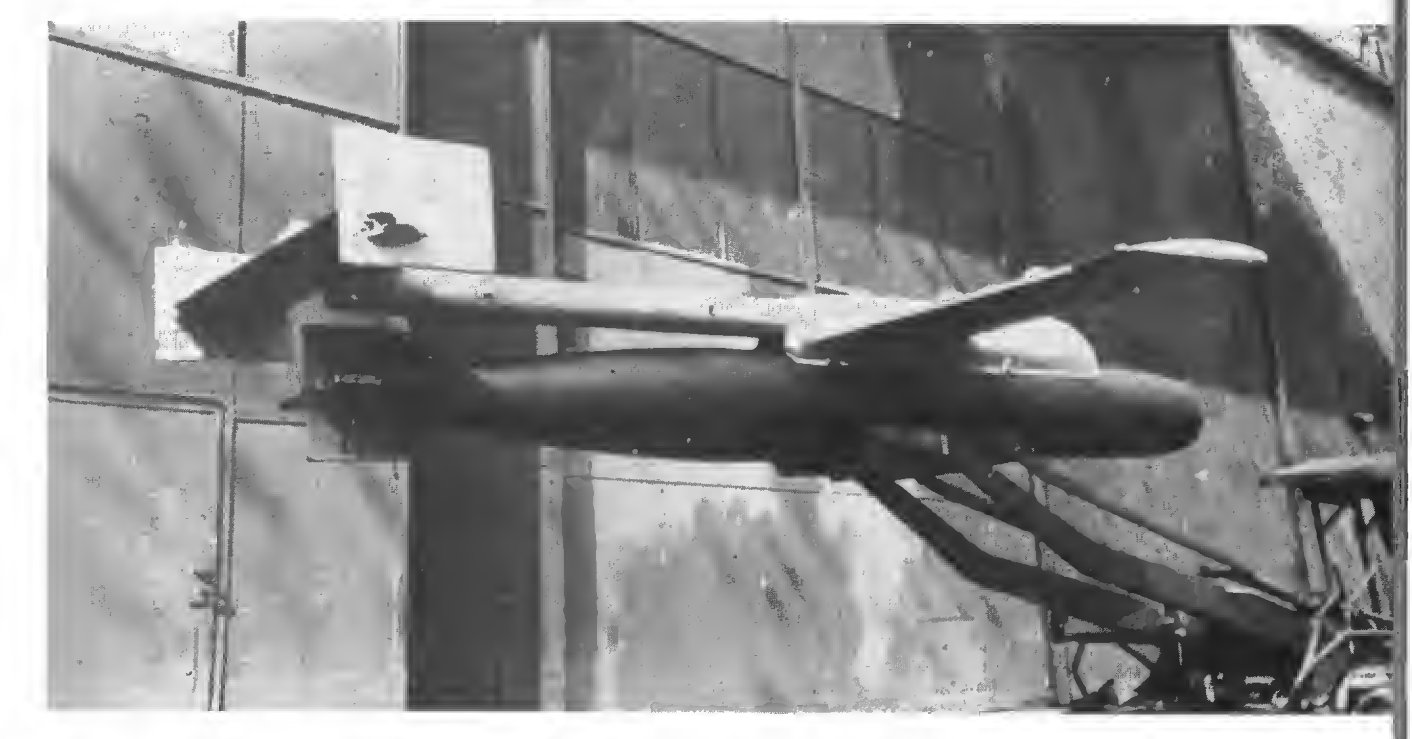
Up to the end of the war, about 450 L 10's were built which were tested in Peenemünde and Gotenhafen-Hexengrund, wherein Ar 234's, Fi 167's, Fw 190 F's, He 111 H and J's, He 177's, Ju 88 A-4's Ju 188 E's, Ju 388 L-0's and Me 410's were utilized as carrier aircraft. The L 10's were not used at the front.

A further development of the L 10 was the L 11 torpedo carrier called the "Schneewittchen" (Snow White) which carried the torpedo in two sections of its fuselage and dropped the torpedo in a similar manner as the L 10. The aircraft to carry this was intended to be the Blohm & Voss P.204 project. The RLM turned down this concept due to its heavy price of RM 15,000 per item and the project never reached the testing stage.

In early 1945, the L 50 torpedo glider was proposed by the Gerätwerk Stargard in Pommern as a special weapon to combat the allied gliders in the North Sea which were supplying the USSR with highly valued war materiel. The actual torpedo was intended to be the "Geyer" which in many respects had similar qualities as the T-5 "Zaunkönig" in use with the Kriegsmarine. This was supposed to receive delta-shaped wings and stabilizers and work with a towed sonde in the same manner as the L 10 and L 11. Because the project was originally planned to be finished in March of 1946, not even the necessary wind tunnel testing of this weapon could be completed.

The Blohm & Voss firm had already suggested a steerable above-water torpedo in the Fall of 1940, which was hoped to not only double the accuracy, but also triple the range of a normal LT. The torpedo was to be dropped from a 1,500 meter altitude and, driven by a rocket engine, glide down to the surface of the water and continue on a level



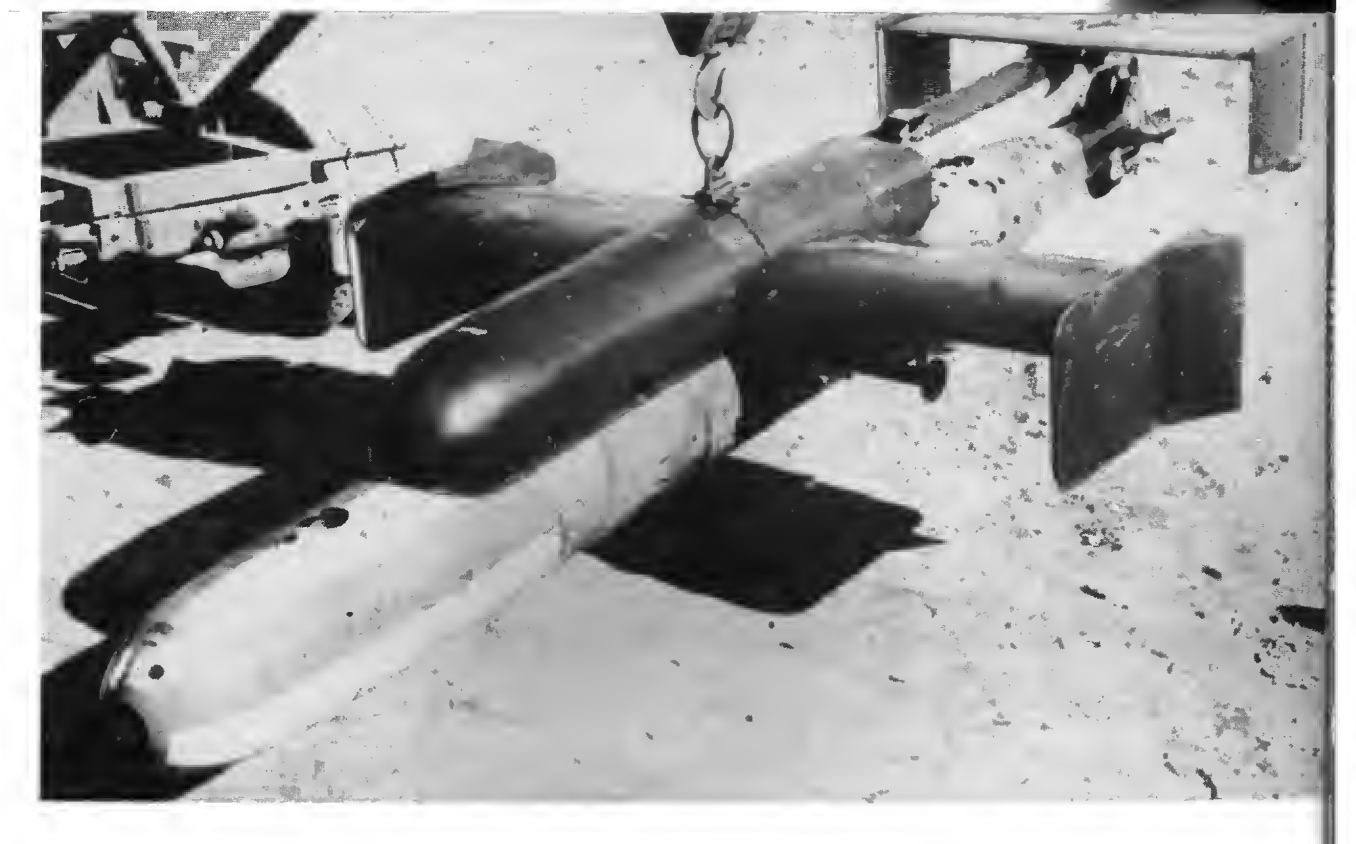


First version of the L.10 "Friedensengel" torpedo glider with the Lt 950 torpedo.



The L.10, model LT 950 D, with its forward section exposed, showing the installation of its elctronic systems.

Right: The L.10 "Friedensengel" with a dummy practice torpedo during testing at Gotenhafen-Hexengrund.





This Heinkel He 177 A-3, tail number TM+1F, has just released an L.10 "Friedensengel" torpedo glider.



A Heinkel He 111 J-1 with an L.10.



A Messerschmitt Me 410 A-1 with an L.10.



The load of two L10's proved to be too much for the Ju 88 A-4.



The Dornier Do 217 K-3 seemed much better suited for this task.

flight path. Only 0.5 seconds after launch, a sensor was deployed which, when sensing the water, opened a compressed air vent which operated first the flaps and then the elevator, making Bv 143 climb from two to 12 meters. This maneuver was repeated several times en route to the target, until, in the final phase, the "Hamburg" target acquisition device assumed the guidance duties.

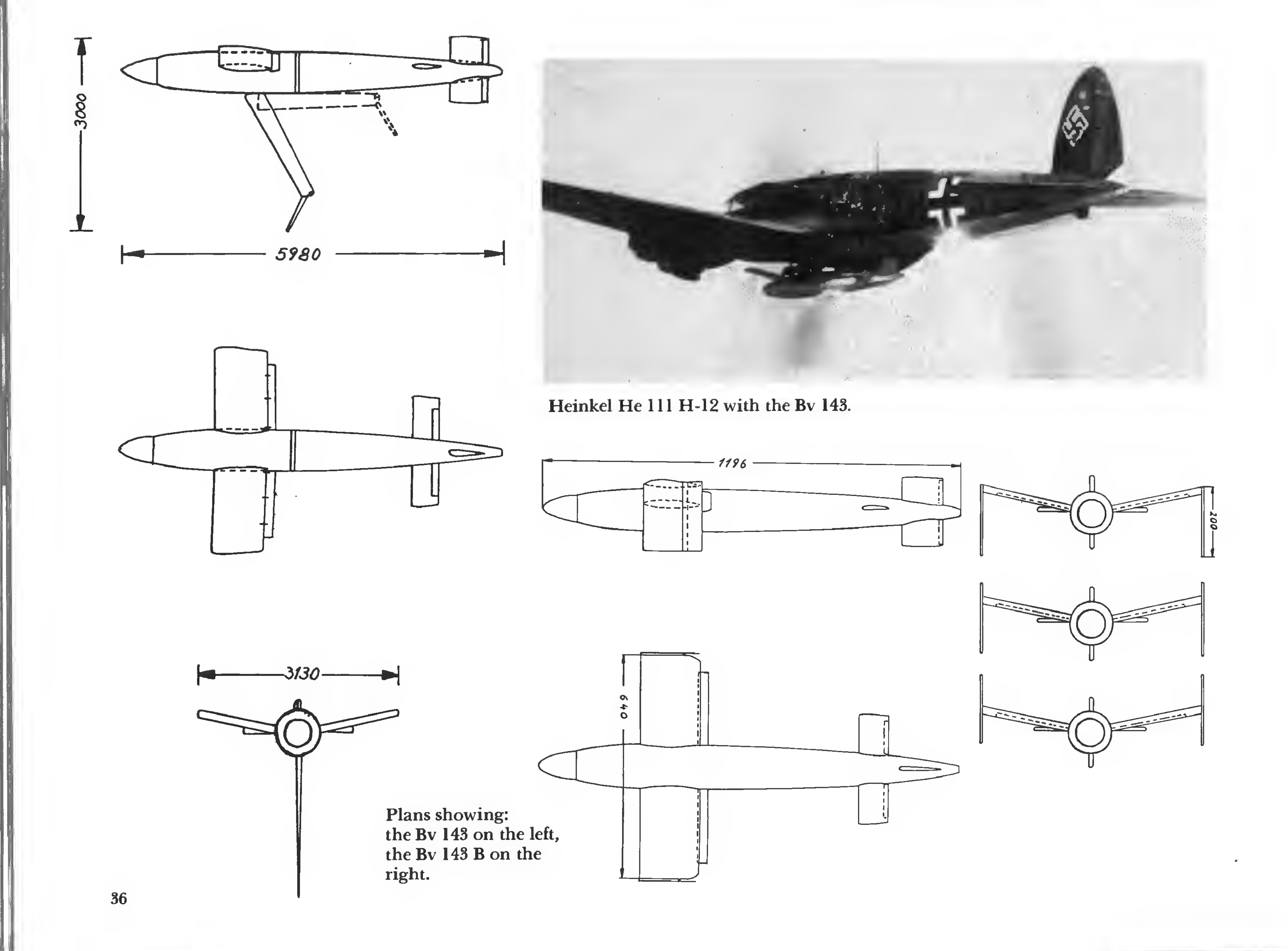
The Walter-Startrakete 109-501 was to be the engine. Two hundred were originally built, this number later being increased to 250. The testing with an He 111 H-6 as the carrier aircraft was conducted beginning in February 1941 in Zinnowitz, east of Peenemünde. Although the Bv 143 V 17 was able to attain a range of 24 kilometers in three minutes and 40 seconds after an engine burn time of only 70 seconds, a continuing problem was the rocket's ability to sustain altitude above the water's surface. Therefore, after only a small number had been produced, the entire project was stricken.

Because the Kriegsmarine had begun to show interest when the Bv 143 was presented as a catapult-launched weapon, Dr. Vogt began to re-built the weapon accordingly at the Blohm & Voss firm. And so the Bv 143 B came into being, despite the fact that the Bv 142 A-2 had already been call the "B" version. The wings and stabilizers had small end-surfaces which small rudders, causing the wingspan of the rudder to be not very much smaller than the wings themselves. At least one example of this catapult-launched weapon was tested. It was not deployed at the front.



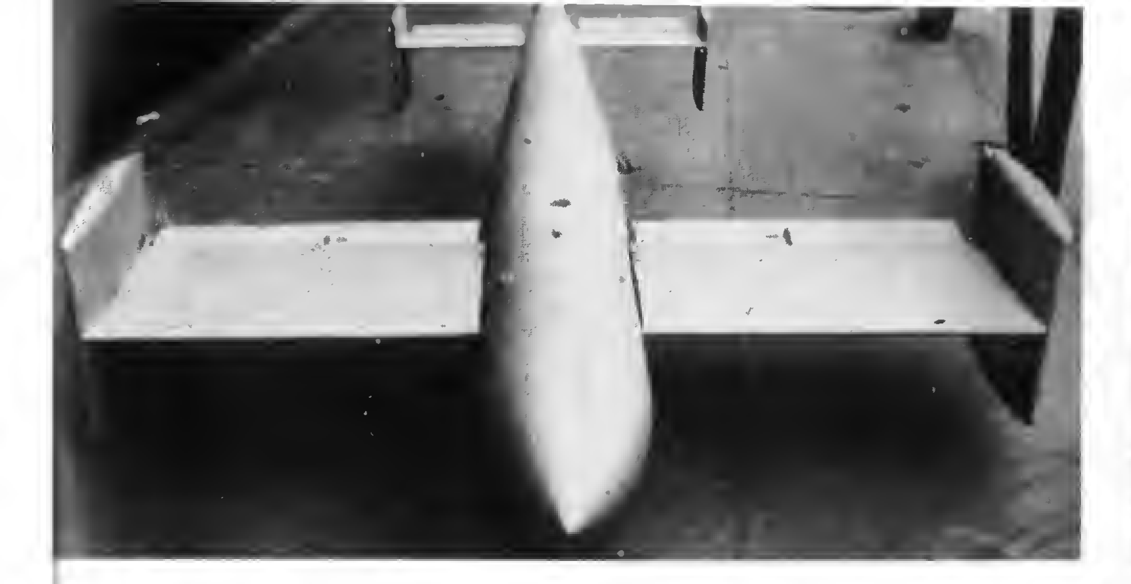
It was hoped that accuracy and range of the torpedo would be increased with the steerable Bv 143 over-water torpedo.





Heinkel He 111 H-12 with the Bv 143.

Plans showing:
the Bv 143 on the left,
the Bv 143 B on the
right.



Front view of the Bv 143 B



The Bv 143 B was originally designated as the Bv 143 A-2.



Testing of the catapult launched version of the Bv 143 B in Radom (in Poland).



A Bv 143 B on the catapult prior to launch (four were fired).

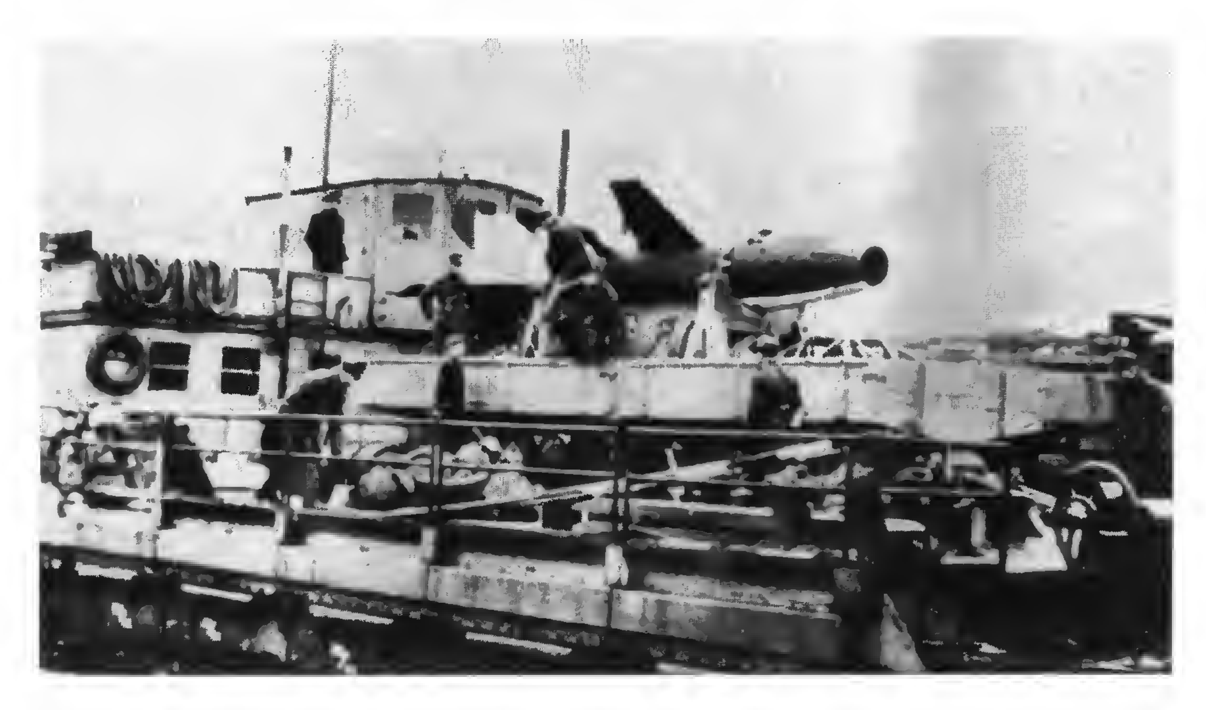
Air Defense Missiles

The first motivation for the development of missiles for purposes of air defense was the desire for a radio guidance system for target depiction for anti-aircraft artillery. By the year 1936, the Argus-Flugmotorenwerke firm was working together with the DFS on a *Flakzielgerät FZG* aerial target. From the experimental Mo 9 prototype came the Mo 12, later called the As 292. It had a wingspan of 2.4 meters and could reach a speed of 90 km/h with a three horsepower engine. Dr. Kloepfer of the Lorenz firm developed the FuG 204 "Kehl II" radio transmitter system in 1939/1940. The receiver was situated in the rod-shaped fuselage of the As 292. In November 1939, Generalluftzeugmeister Ernst Udet viewed this successfully tested device and 100 such items were manufactured.

A larger version with a camera installed was to serve as an unmanned reconnaissance vehicle. Those "drones" developed in the USA after the war already had predecessors in Germany. The steady deployment of enemy bomber units over the German Reich showed that the anti-aircraft artillery would soon reach its effective limits. Therefore, the General der Flakartillerie, General von Axthelm, was able to issue an order on September 9 1942 for the development of anti-aircraft rockets, or *Fla-Raketen*. Even before the end of 1942 the RLMz awarded the research contract for the Fla-Raket called "Wasserfall" to the *Flakversuchsanstalt* in Karlshagen near Peenemünde, which conducted the research under the direction of Dr. ing. Haase. From that point on, this facility was known as the "*Flak-Versuchskommando*



Ernst Udet viewing the "Flakzielgerät" (FZG) Argus As 292.



A "Wasserfall" anti-aircraft missile being transported to Peenemünde via ship.



The "Wasserfall" with an early wing version.

The "Wasserfall" in its final form prior to launch.



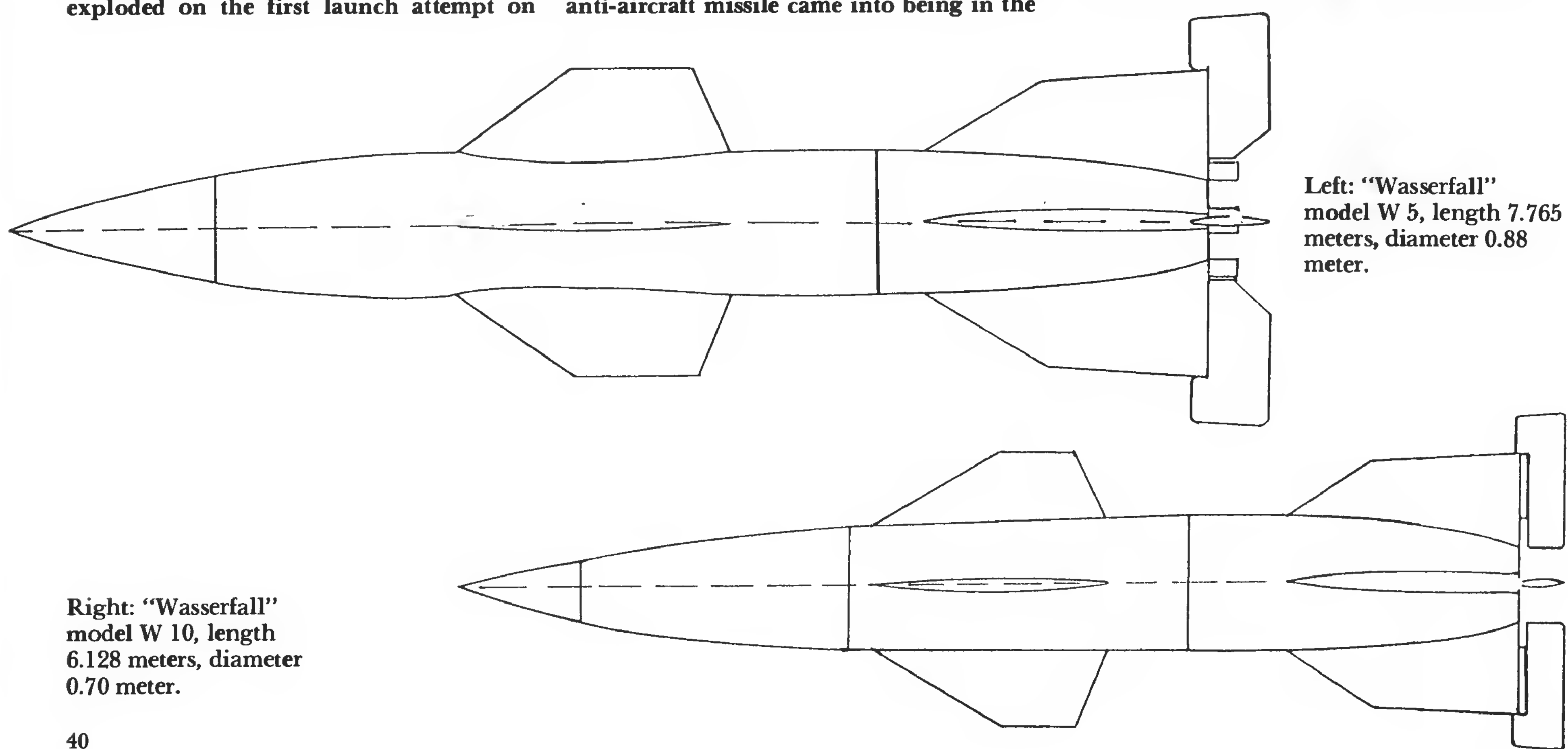
The "Wasserfall" in ascent.

Nord" and was technically subordinate to Dr. von Braun. Although the expansion of a new test facility P IX had been ordered in November of 1942, the actual expansion and work on the "Wasserfall" project did not begin until the Summer of 1942, after Göring had given his clearance for the project on December 17th 1943. The final production work on the "Wasserfall" could not begin until April 20 1943 as the necessary technicians had to be called back from front-line units one by one.

Externally, the "Wasserfall" looked like a miniaturized A.4 (V 2). The first test model exploded on the first launch attempt on January 8 1944. On February 29th, the second model was successfully launched from P IX and reached a maximum speed of 2,772 km/h in vertical flight. About fifty of these were tested. There was no mass production by the Arado and Henschel firms after this. Beginning in September 1944, the *2. Batterie der Flak-Lehr- und Versuchsabteilung* began comparative firings of various anti-aircraft missile models. Of all the anti-aircraft missiles developed in Germany, the "Wasserfall" was probably the most powerful, but also the most complex and elaborate.

Due to the fact that the successful NIKE anti-aircraft missile came into being in the USA shortly after the war and was developed with the cooperation of Dr. von Braun, the "Wasserfall" can be seen as the predecessor to the NIKE.

The price of the "Wasserfall" lay between RM 7,000- and 10,000-. This meant that a direct hit cost about RM 14,000- while at the same time it would take about 4,000 anti-aircraft artillery shells to achieve the same results — at a cost of 400,000-. Production of the "Wasserfall" was stopped on February 26 1945, despite that fact that on its first deployment, about fifty were used, a decisive victory was achieved against enemy bombers.



Left: "Wasserfall" model W 5, length 7.765 meters, diameter 0.88 meter.

Right: "Wasserfall" model W 10, length 6.128 meters, diameter 0.70 meter.

Prof. Herbert Wagener of the Henschel firm had proposed the idea of the Hs 297 anti-aircraft missile to the RLM in 1941. Because the thinking of the RLM at this point in time was that such a weapon would be superfluous, the project was turned down. In 1943, however, it was suddenly a matter of great urgency and its development was ordered conducted at the highest level of priority. Dipl.Ing. Henrici was entrusted with the development of the anti-aircraft missile,now called the Hs 117. By the end of early 1944, there stood a sub-sonic rocket with mid-mounted tapering wings. Two solid fuel engines were the propulsion unit for launch, which later separated from the missile leaving propulsion to the liquid-fueled Walter HWK 107-729. A special carriage was used for inclined launches. Guidance was conducted via radio. In the first 21 launches conducted between May and November 1944, altitudes of up to 11,000 meters were reached. The Hs 177 was, next to the "Wasserfall," the only anti-aircraft missile which was deployed, albeit only for a short time.

When, in 1944, the "Kommission zur Brechung des feindlichen Luftterrors" demanded a quick solution for the large caliber air-launched missile problem, the Hs 117 H (without launch engines) came into being. The engines were BMW 109-558. After initial gliding trials in 1944, 28 Hs 117's were tested successfully. In January 1945, the first mass-produced missile was ready. Then, on February 6 1945, development and production of the Hs 117 was put to a stop by order of *SS-Obergruppenführer* Kammler, who was responsible for V-weapons. This was the end of an effectiveweapon against enemy bomber formations. Still, on January 14 1945, prof. Wagner proposed the S II (Schmetterling)



Above: The Henschel Hs 117 "Schmetterling" anti-aircraft missile.



Right: Control surfaces and vents of the Hs 117's solid fuel rocket boosters.



The Henschel Hs 117 on the launch ramp.



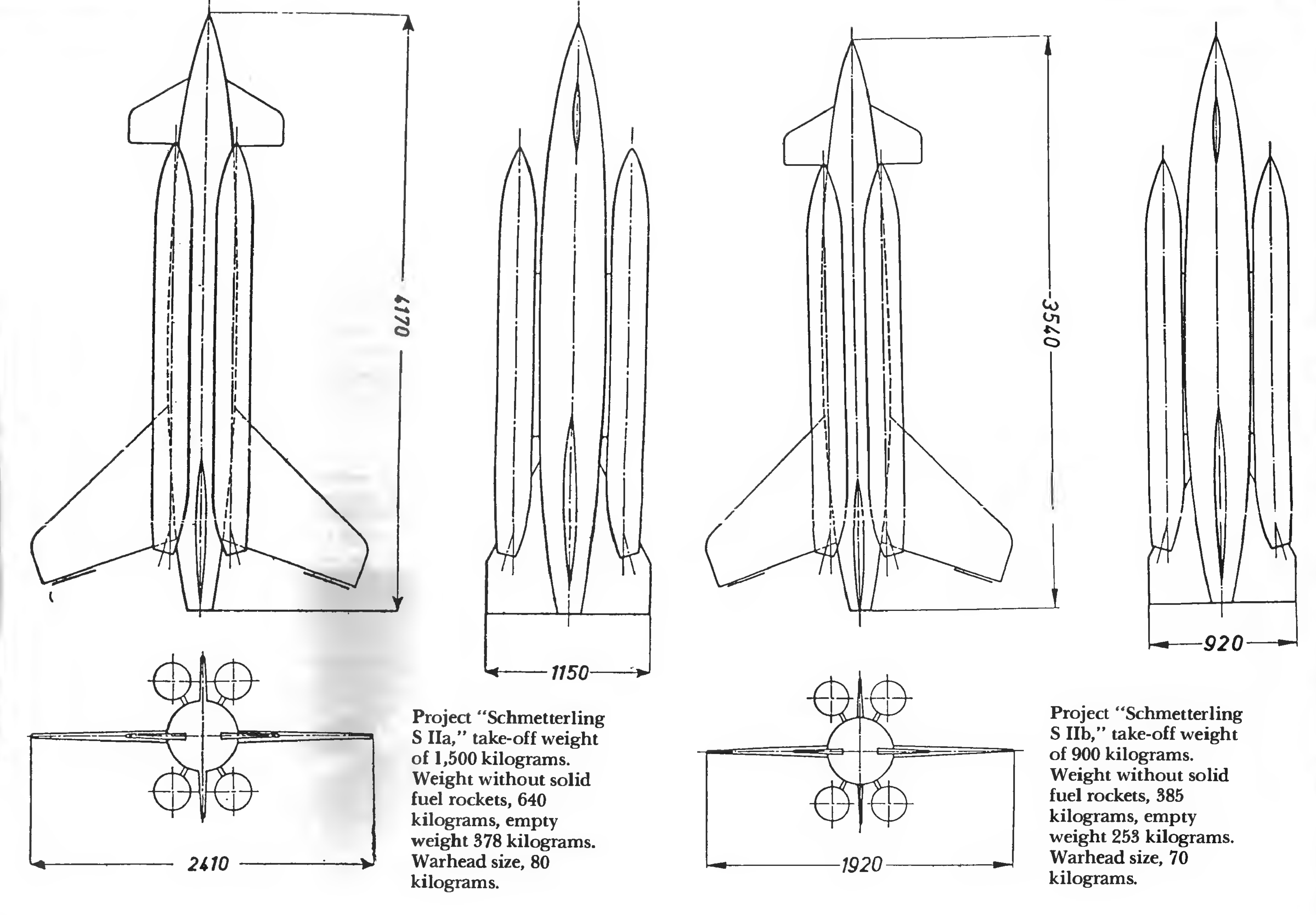
Hs 117 "Schmetterling's" on their ramps prior to launch.



An Hs 117 launch at Schönefeld in 1943.



Air-launched Hs 117 H being dropped from an He 111.



Project "Schmetterling S IIa," take-off weight of 1,500 kilograms. Weight without solid fuel rockets, 640 kilograms, empty weight 378 kilograms. Warhead size, 80 kilograms.

Project "Schmetterling S IIb," take-off weight of 900 kilograms. Weight without solid fuel rockets, 385 kilograms, empty weight 253 kilograms. Warhead size, 70 kilograms.

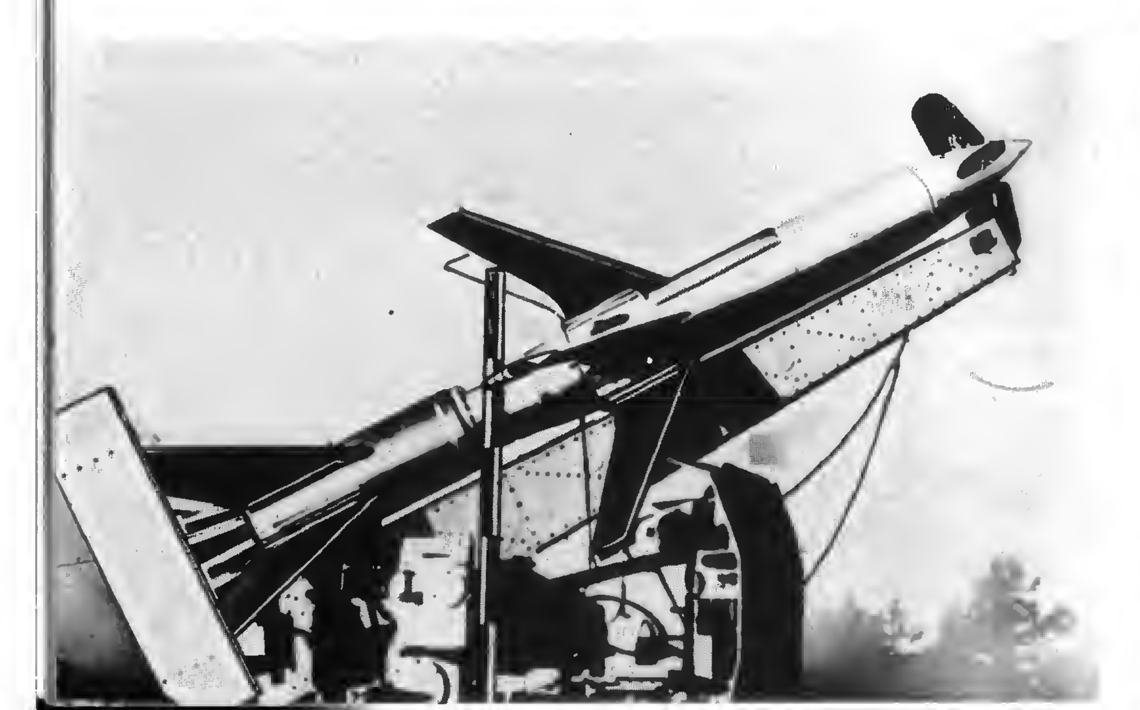
project as a further development of the Hs 117 "Schmetterling." Two days later it was adopted at the anti-aircraft test facility. However, the continuation of this project by the *Oberkommando der Luftwaffe*, as explained above, was not to be.

The Rheinmetall-Borsig AGzfirm in Berlin-Marienfelde, which was a leader in many areas of arms manufacture, began testing solid fuel (gun powder) rockets before 1939 under the leadership of Direktor Kelin and Dr. Vüllers, and intensively worked on rocket launches and engines. The first attempts at an anti-aircraft missile were based on the gK-1750 "Hecht" gliding bomb, of which a couple of test models were built in 1941. This model was changed twice, and then cut due to the run-up of the Hs 293 A-1 series. Later, the FK "Hecht 2700" came from this model. This test model was the basis for the "Feuerlilie" anti-aircraft missile, from which stemmed the F 25 subsonic version and the supersonic F 55, F 55A and F 55B versions. A few example of the F 25 were tested and deployed, but development of the F55-versions had, however, not been completed by war's end.

In 1942, Rheinmetall began with the development of a two-stage anti-aircraft missile called "Rheintochter" which was mistakenly designated a long-range missile. It was originally planned to be a two-stage missile at a total weight of 1,700 kilograms carrying a 150 kilogram warhead. The intensification of aerial defenses demanded the creation of several versions. Of these, several versions of the R I were tested at the front, while the R III could no longer be produced. As a research study, models were built in the scale of 1:2.5, which provided important information about aerodynamic stability. In the first test firings, the missile achieved a speed of 220 meters per second. However, the R I was only able to reach an altitude of 6,000 meters at a range of 40 kilometers. Gun carriages served as launch ramps.

Direktor Klein and Dr. Vüllers also developed a long-range missile based on the "Rheintochter," which was the Rh.Z.61/9 "Rheinbote." It wa a four stage rocket which was about eleven meters long. Its range was supposed to be 220 kilometers. Similar to the Peenemünde V 2, the "Rheinbote" was to be launched from a mobile platform.

The "Rheintochter R I" on the launch ramp.



The "Rheintochter R I" at a captured weapons show after the war.



The main difference between the V2 and the "Rheinbote" lay in the engine, because each stage was a solid fuel motor (diglycol powder). In comparison with the V2, the performance was decidedly more modest, because while the V 2 missile carried a warhead of 975 kilograms, the warhead on the "Rheinbote" was only 20 kilograms!

At the Oberbayerischen Forschungsanstalt Oberammergau, which was a sister company of the Messerschmitt plant, the "Enzian" anti-aircraft missile was created in 1944. The requirement for a simple weapon and one which was cheap to produce had been met: the entire fuselage, the form of which followed the Lippisch Me 163, consisted of wood, with the exception of the nose section, which was made of 20mm sheet metal. The propulsion unit was the VfK-Triebwerk Zg.613 A 01, the most primitive liquid fuel engine of all anti-aircraft missiles. Only proven ground and on-board systems were used so that no additional developmental time was necessary. Production of the 60 or so "Enzian" missiles built before the end of the war was done by the Holzbau Sonthofen firm.

The "Enzian" used four jettisonable solid fuel rocket booster for launch, after which the liquid fuel engine assumed the propulsion, bringing the missile to a height of 15,000 meters. The first launching of the "Enzian" took place in August of 1944. The polar guidance of only a pair of rudders was done via radio remote control.

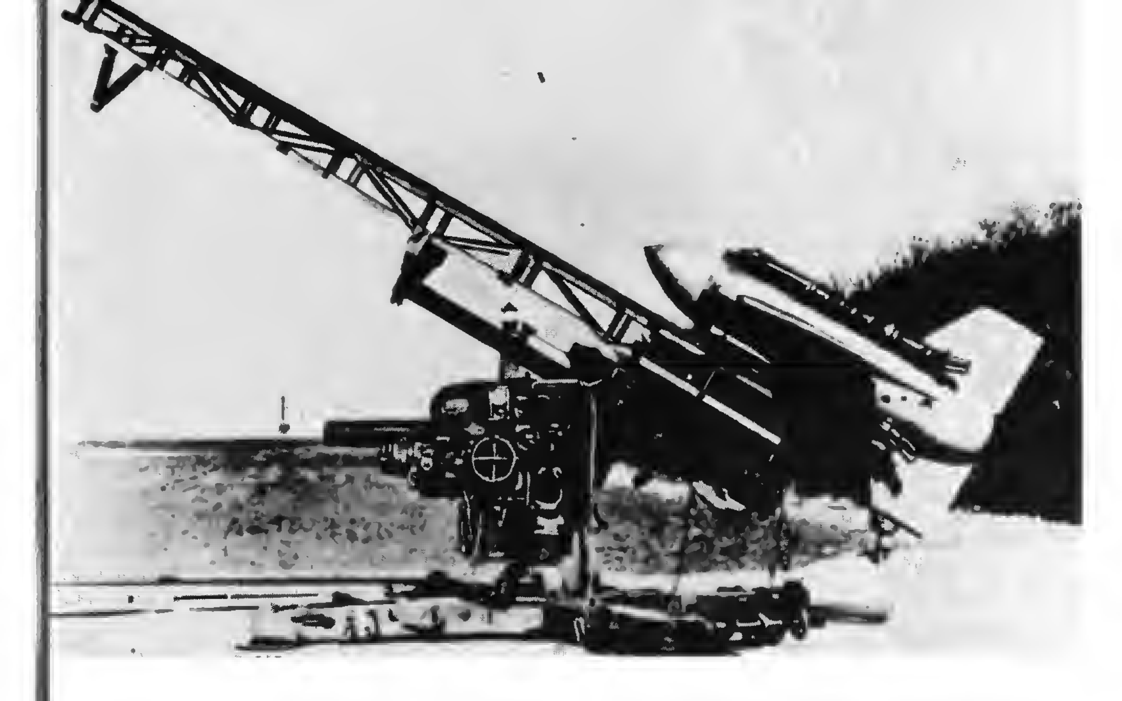
In addition to those radio systems already outlined, the following methods were tested and utilized: "Rheinland," "Düren-Detmold," Düsseldorf-Detmold," FB-transmission method and the FZ 11, NY and DFS transmission methods. The leadership for the development of radio guidance technology was provided by Dr.Ing. W.T. Runge and the ***GBN-Entwicklungsgruppe 10 "Fernlenktechnik"*** developmental team.



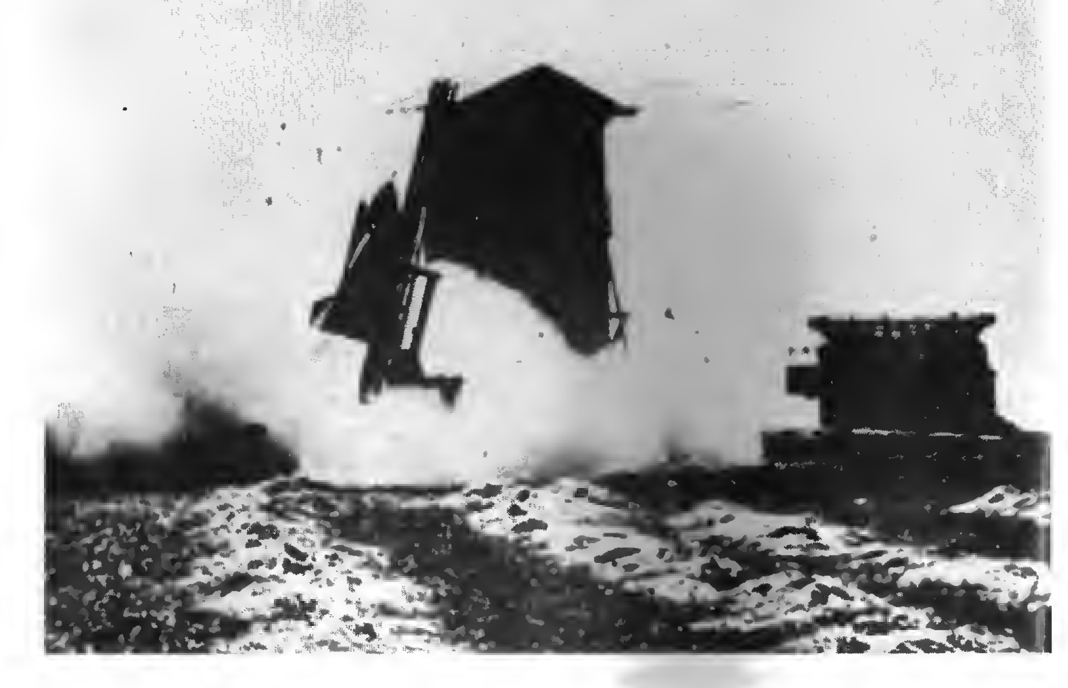
An anti-aircraft missile, the Rheinmetall "Feuerlilie F 25," prior to launch.



Long-range Rheinmetall "Rheinbote" Rh.Z. 61/9 on the launch ramp.



The Messerschmitt "Enzian" anti-aircraft missile on an Flak 8.8cm gun chassis.



An "Enzian" on the launch ramp with the "Würzburg-Riese" guidance system.



The "Enzian" lifts off.



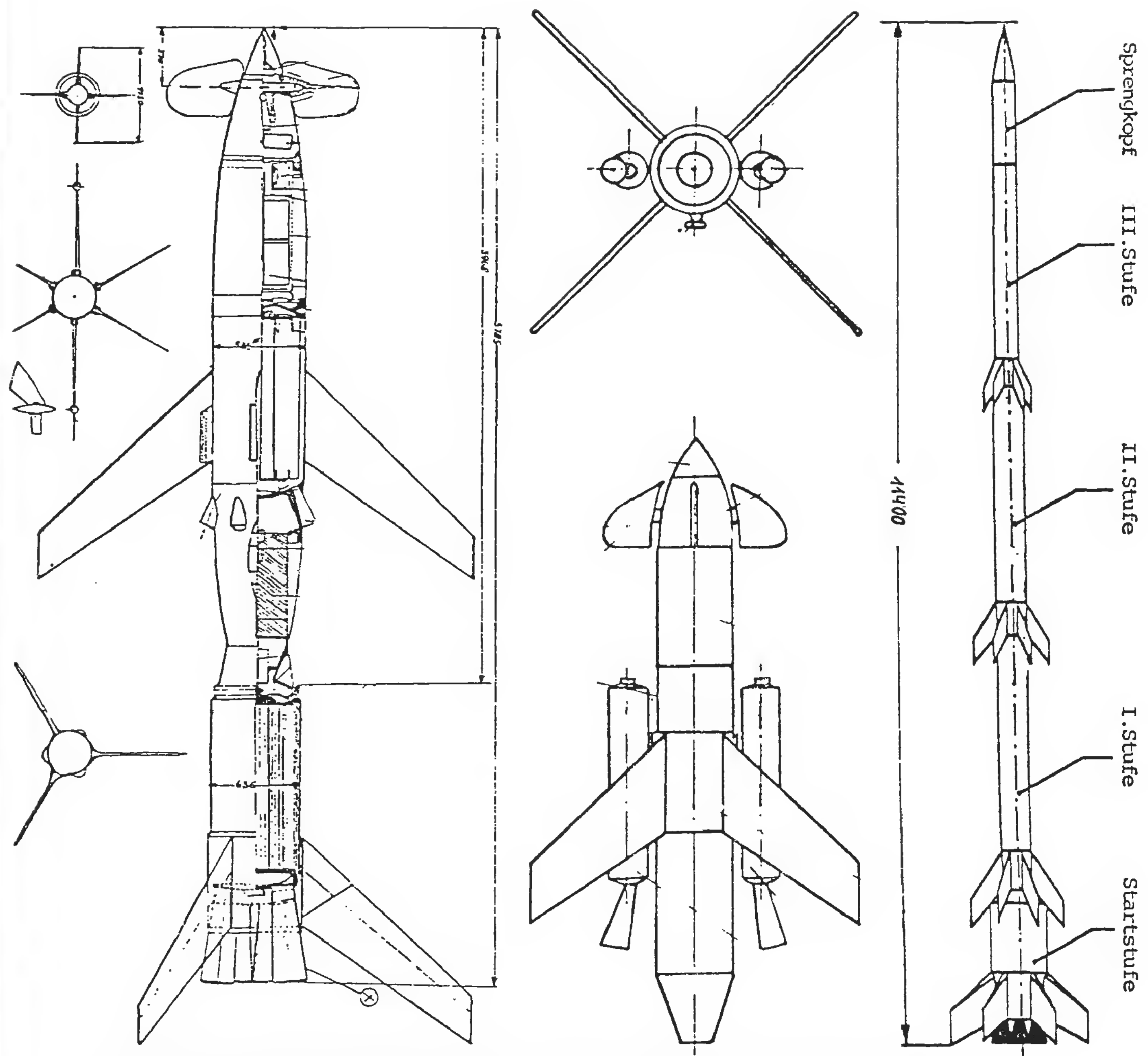
"Enzian" shortly after take-off.

Technical Data

TYPE	RZ 65	RZ 73	RZ 100	W.Gr.21	R 100 BS	Panzer-schreck	Panzer-blitz I	Panzer-blitz II	R 4/M	X4	X7
length (mm)	262	330	1650	1177	1840	800	705	815	812	2001	758
fuselage diameter (mm)	73	73	420	210	282	100	93	130	55	222	148
wingspan (mm)	–	–	–	–	320	230	200	–	242	725	600
wing area (cubic meters)	–	–	–	–	1.06	–	0.43	–	–	4.4	–
total weight (kg)	2.780	3.167	730	111	110	8.0	6.54	5.10	3.85	60.5	9.0
fuel load (kg)	0.685	0.583	85	18.4	20.0	–	1.030	–	0.815	8.8	6.5
explosive weight (kg)	0.130	0.280	245	38.6	40.0	–	2.10	2.10	0.520	20.0	0.130
thrust (kiloponds)	300	680	–	1720	3200	–	440	–	245	140	68/5.5
speed (meters per second)	260	360	–	315	450	135	374	370	525	248	98
range (meters)	250	400	–	2200	2000	–	–	–	1500	5000	1200

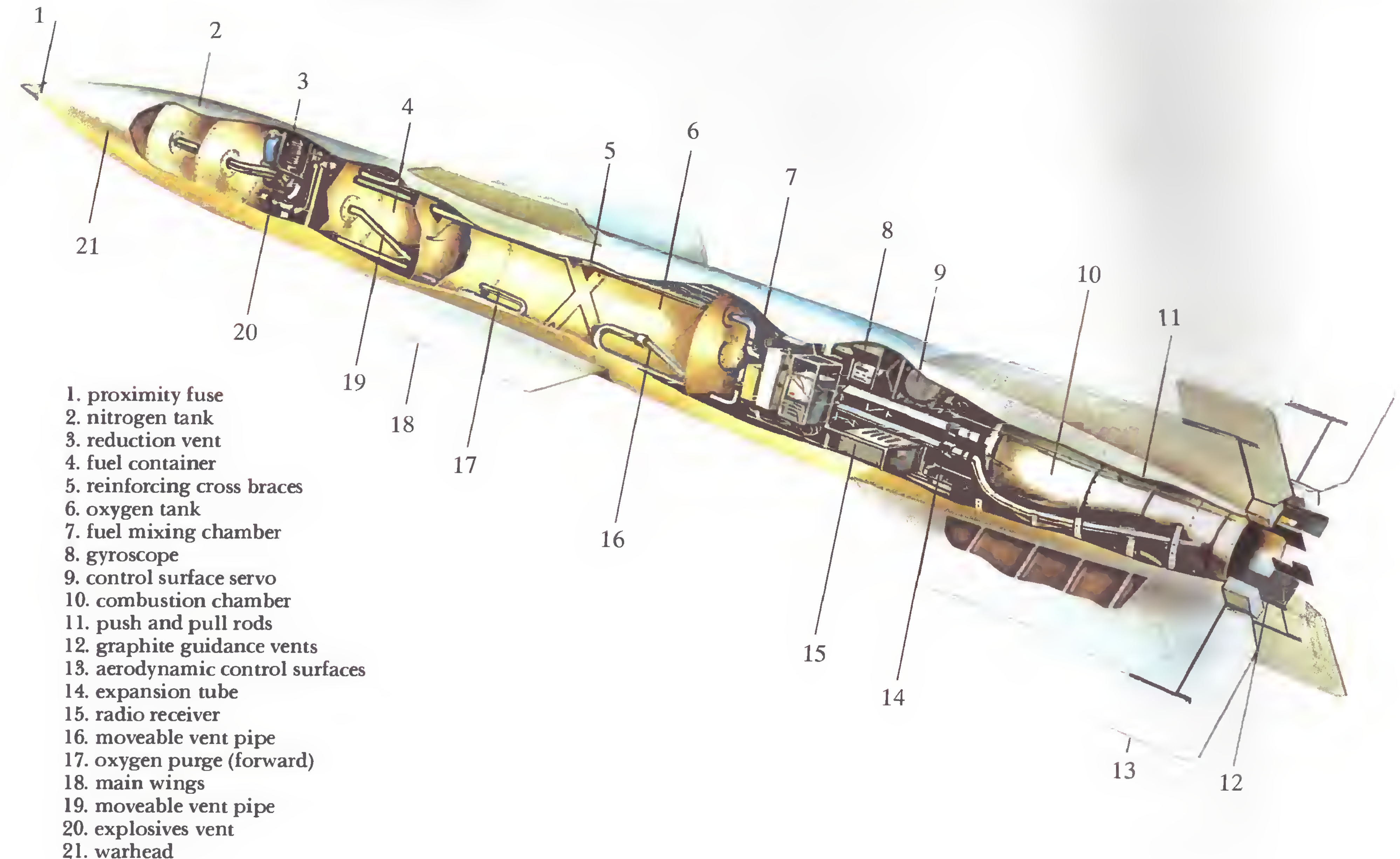
TYPE	Hs 298	Fritz X	Hs 293A	Hs 293F	Hs 294	Hs 295	Peter X	Hecht	Bg 3/L	Bv 246	L10
length (mm)	2003	3262	3818	3200	6114	5443	3290	1750	3000	3525	3894
fuselage diameter (mm)	415	562	470	470	620	579	536	177	–	542	440
wingspan (mm)	1290	1352	3100	1600	4025	4087	1630	588	1500	6408	2500
wing area (cubic meters)	0.42	–	1.92	1.92	5.30	5.40	–	–	2.25	1.47	2.06
total weight (kg)	95.0	1570	975	–	2170	2090	1775	–	250	730	218 o.LT
fuel load (kg)	9.5	–	66	–	–	–	–	–	105	–	–
explosive weight (kg)	25.0	320	295	–	630	585	–	–	100	435	–
thrust (kilopounds)	150/50	–	600	–	1300	1300	–	–	–	–	–
speed (meters per second)	234	343	265	–	245	235	–	–	–	–	87
range (meters)	1600	–	–	–	–	–	–	–	530	210	9000

TYPE	L 11	LT 9.2	Bv 143	Wasserfall	Hs 117	F 25	Rheinbote	Rhein-tochter R1	Rhein-tochter R3	Enzian
length (mm)	6345 m.LT	5100	5980	7450	4030	2080	11020	10300	4750	3750
fuselage diameter (mm)	–	–	585	680	–	250	535	510	510	–
wingspan (mm)	3430	2000	3130	1890	2000	–	–	2750	–	4050
wing area (cubic meters)	3.9	2.0	2.46	–	–	–	–	–	–	4.9
total weight (kg)	1048 m.LT	–	1058	3500	420	120	1750	1750	976	1800
fuel load (kg)	–	–	162	1860	–	–	2240	460	536	–
explosive weight (kg)	–	–	180	150	23	17	20	100	415	320
thrust (kiloponds)	–	–	500	–	375	–	9800	–	–	–
speed (meters per second)	120	–	115	770	23	–	–	1750	–	1000
range (meters)	1100	–	–	–	–	–	220 km	40	–	25



Drawings of the "Rheintochter R I" on the left, the "Rheintochter R III" in the center, and the "Rheinbote" on the right.

Cutaway view of the "Wasserfall," which clearly shows how much room was required for the radio controlled guidance system.





The Ajax missile display near San Pedro, south of Los Angeles California. The Ajax surface-to-air missile is based on the "Rheintochter R III."

The "Fritz X" was an anti-ship weapon, its penetration power was sufficient enough to sink a ship. The enemy was curious as to why the Luftwaffe did not build thousands of these guided bombs.

1. warhead with 300 kg of amatol
2. suspension points
3. main fuse receptacle
4. 7-pin flange
5. hot air regulator
6. outer tail section ring
7. control interrupter
8. main control device (Wagner-Riegel above and below)
9. exhaust jets
10. main control chamber and radio systems
11. access panel for the control chamber
12. four wings
13. central explosive tubes
14. armor piercing warhead

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